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RISK AND THE AEROSPACE RATE OF RETURN

Irving N. Fisher and George R. Hall

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PREFACE

This Memorandum is part of RAND's continuing program of procurement research. It does not deal with specific procurement policies, however, but focuses on one aspect of the general subject of defense industry performance -- the rate of return of aerospace firms.

The study examines earnings of firms in the aerospace and other industries relative to their risk exposure. On the basis of restrictive but reasonable assumptions, the study estimates the risk component of earnings for these firms. The study concludes that the risk-adjusted rates of return for the aerospace firms are fairly high compared with those of other industry groups, but emphasizes that no conclusion about the adequacy of profits can be drawn from computations of such rates.

SUMMARY

This Memorandum addresses the question of whether the above-average rate of return on net worth earned by aerospace firms results from above-average risk exposure. The study considers some methodological problems encountered in answering this question, and presents empirical estimates of risk premiums for aerospace and 10 other industry groups.

The theoretical basis for measuring risk exposure is first developed. Risk is defined as the probability that earnings in some future period will differ from an anticipated value. That is, risk is viewed as the difficulty of forecasting future profits; in general, the more variable the rate of return, the more difficult it is to predict and the greater is the risk. If we assume that, on the average, anticipations are fulfilled, the mean of each firm's actual yearly rate of return can be used as a proxy for the firm's anticipated rate of return. On this basis, risk can be measured by the dispersion of actual yearly earnings from the mean. Standard deviation and skewness are the statistical measures of risk exposure used to compute risk-adjusted rates of return and risk premiums.

Problems of how to measure the standard deviation, adjustments for time trends and autocorrelation, and other theoretical and empirical problems are discussed. Consideration is given to the different results yielded by alternative measures of risk and the impact of various statistical adjustments. Applying the model to a sample of 88 firms for the period 1957-1964 yields the following results:

Industry Group	Average Observed Rate of Return	Rank	Risk-Adjusted Rate of Return	Rank	Average Risk Premium
Drugs	.1832	1	.1664	1	.0168
Aerospace	.1570	2	.1335	2	.0245
Chemicals	.1409	4	.1131	3	.0278
Petroleum	.1147	7	.1026	4	.0121
Rubber	.1096	8	.1021	5	.0075
Food	.1072	9	.0915	6	.0157
Electrical mach.	.1195	6	.0857	7	.0338
Automotive	.1477	3	.0754	8	.0723
Office mach.	.1408	5	.0724	9	.0684
Steel	.0825	10	.0703	10	.0122
Textiles	.0789	11	.0594	11	.0195

As measured by standard deviation and skewness, risk exposure explains about half of the variance in the rates of return of the firms in the sample. Statistically, the standard deviation coefficient is significant at the .01 level of confidence, and the skewness coefficient at the .05 level.

Several inferences are drawn from these results, two of them being particularly important. First, on the basis of some restrictive but reasonable assumptions, it is possible to measure the risk component of nominal corporate profits. Second, for this sample, even after adjusting for risk, the aerospace rate of return is still the second highest.

Many industry groups show a substantial difference between the nominal observed rate of return on net worth and the risk-adjusted rate. The two groups with the highest rates of return, however -- drugs and aerospace -- do not. It appears that the above-average rates of return for these groups are due to factors other than risk-exposure as that concept is defined here.

One caveat should be kept in mind. The purpose of the study was to obtain risk-comparable corporate rates of return, which have many instructive features for those interested in industrial performance. Profits are affected by many factors other than risk. This study does not investigate these factors, nor does it presume to pass judgment on the adequacy of profits.

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CONTENTS

PREFACE iii

SUMMARY v

ACKNOWLEDGMENTS vii

Section

I. INTRODUCTION 1
- Goals of the Study 1
- The Definition of Profits 2
- Comparability Versus Adequacy 7

II. RISK AND THE RATE OF RETURN: THEORETICAL CONSIDERATIONS 9
- The Meaning of Risk 9
- The Basis for a Risk Premium 12
  - Risk Aversion 14
  - Risk Neutrality 17
  - Risk Preference 19
- The Risk Premium and the Distribution of Earnings 20
- Risk and Profit Equilibrium 24

III. RISK AND THE RATE OF RETURN: EMPIRICAL RESULTS 26
- The Measurement of Risk 26
- The Company-Mean Standard-Deviation Approach 36
- Measurement Technique Differences -- A Digression 44
- Adjustments to the Model 46
  - Trend Adjustment 46
  - Autocorrelation Adjustment 49
  - The Revised Relationship 52
- Summary 53

IV. CONCLUSIONS 57
- The Measurement of Risk 57
- Statistical Findings 59
- Implications 62

APPENDIX: FIRMS INCLUDED IN SAMPLE 63

REFERENCES 67

I. INTRODUCTION

GOALS OF THE STUDY

Profits of defense contractors are always a controversial topic. Particularly subject to dispute are the earnings of the aerospace firms that develop and produce major weapon systems. Unfortunately, controversy has stimulated more polemics than research; moreover, most discussion has centered on the issue of whether profits have been adequate rather than on the factors that determine the rate of return of contractors. This study explores a part of the neglected area by examining the relationship between risk and aerospace profits and comparing the risk component in aerospace earnings with estimated risk premiums for other industries.

The study has two goals. The first is to examine the concept of risk premiums and how they might be measured. The second is to measure the component of earnings that seems to be associated with risk-exposure for selected firms in eleven industry groups. On the basis of this measurement, estimates of average risk-adjusted profit rates for the various industry groups are obtained. Some inferences are drawn about the comparability of aerospace profits with the rate of return in other industries after making allowance for uncertainty.*

This introduction considers the definition of profits and some related issues. Section II considers the theoretical basis for a risk premium and the statistical models used to test the relationship between profits and risk-exposure. Section III presents the empirical evidence. The risk component of earnings is estimated for each of the industry groups, and nominal profit rates are adjusted to yield risk-comparable profit rates. Finally, Sec. IV considers the implications of the empirical findings.

The analysis is focused on aerospace industry profits and especially on the profits of 10 large contractors.** Table 1 and Fig. 1

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*The terms "risk" and "uncertainty" will be used synonymously. Compare Refs. 6, 9, 11, 18, and 34.

**The Boeing Company, Cessna Aircraft Company, Curtiss-Wright Corporation, Douglas Aircraft Company, Inc., Lockheed Aircraft

present the yearly figures for sales, net worth, and profits for these firms. For comparison, some figures for a larger sample of 51 firms are also presented. Note that the 10-firm sample accounts for a sizeable part of the sales and profits of the larger sample, increasing from about half in 1956 to nearly two-thirds of total sales in 1964.

Several trends are evident in the rate of return on both sales and net worth. During the 1954-1957 period the rate of return appears to have increased, while during the 1959-1961 period it fell. Since 1962, however, the rate of return has again been rising. Profits in the aerospace industry, measured either in terms of sales or net worth, have been erratic.

THE DEFINITION OF PROFITS

The term "profit" as used here is roughly equivalent to net business income, i.e., the difference between accounting revenues and accounting costs. In contrast, "profit" in economic literature refers to the reward for the functional contribution of entrepreneurship.* Accounting profit includes not only economic profits but portions of other functional returns such as rents, interest, and wages as well as the results of chance factors. Thus, accounting profit is a heterogeneous amalgamation consisting primarily of payments not set by contractual agreement.** As a result, accounting profit has serious limitations for analytical studies. On the other hand, data are not available on profit defined in a strict theoretical basis. Consequently, the accounting definition is adopted.

Corporation, McDonnell Aircraft Corporation, North American Aviation, Inc., Northrop Corporation, Republic Aviation Corporation, United Aircraft Corporation. See the Appendix for a list of the other firms included in the study.

*See Refs. 17, 18, 27, 34.

**This statement is a first approximation. Some contractually-set payments are included in accounting profits, e.g., dividends on preferred stock. Some economic profits may show up in figures other than accounting profits, e.g., bonuses to managers. Still other exceptions can be found to the general rule that accounting profit consists of those payments not set contractually. (See Stigler [30] p. 9.) For present purposes, however, the general rule that accounting profit consists of all noncontractually fixed factor payments is sufficient.

Table 1

SALES, NET WORTH, AND PROFIT IN THE AEROSPACE INDUSTRY, 1951-1964

(In $ million and perc)

Year	51-Firm Sample			10-Firm Sample				
	Sales	Profits[a]	Rate of Return on Sales[a]	Sales	Profits[a]	Rate of Return on Sales[a]	Net Worth	Rate of Return on Net Worth[a]
1951				2,098	59	2.81	616	9.57
1952				4,198	97	2.31	657	14.76
1953				5,872	133	2.26	755	17.62
1954				5,862	205	3.61	883	23.21
1955				5,970	231	3.86	1,021	22.63
1956	11,011	347	3.15	6,696	231	3.44	1,431	16.14
1957	12,868	377	2.92	8,224	259	3.14	1,411	18.36
1958	12,575	307	2.44	7,914	202	2.55	1,540	13.12
1959	12,488	196	1.55	7,833	109	1.39	1,576	6.92
1960	12,974	185	1.43	7,956	90	1.13	1,580	5.69
1961	13,954	257	1.84	8,321	139	1.67	1,678	8.28
1962	15,206	360	2.36	9,122	201	2.21	1,793	11.21
1963	15,313	350	2.28	9,862	201	2.03	1,917	10.49
1964	15,404	395	2.56	10,008	237	2.36	2,040	11.61

SOURCE: Corporate reports and Ref. 1.

[a]After taxes.

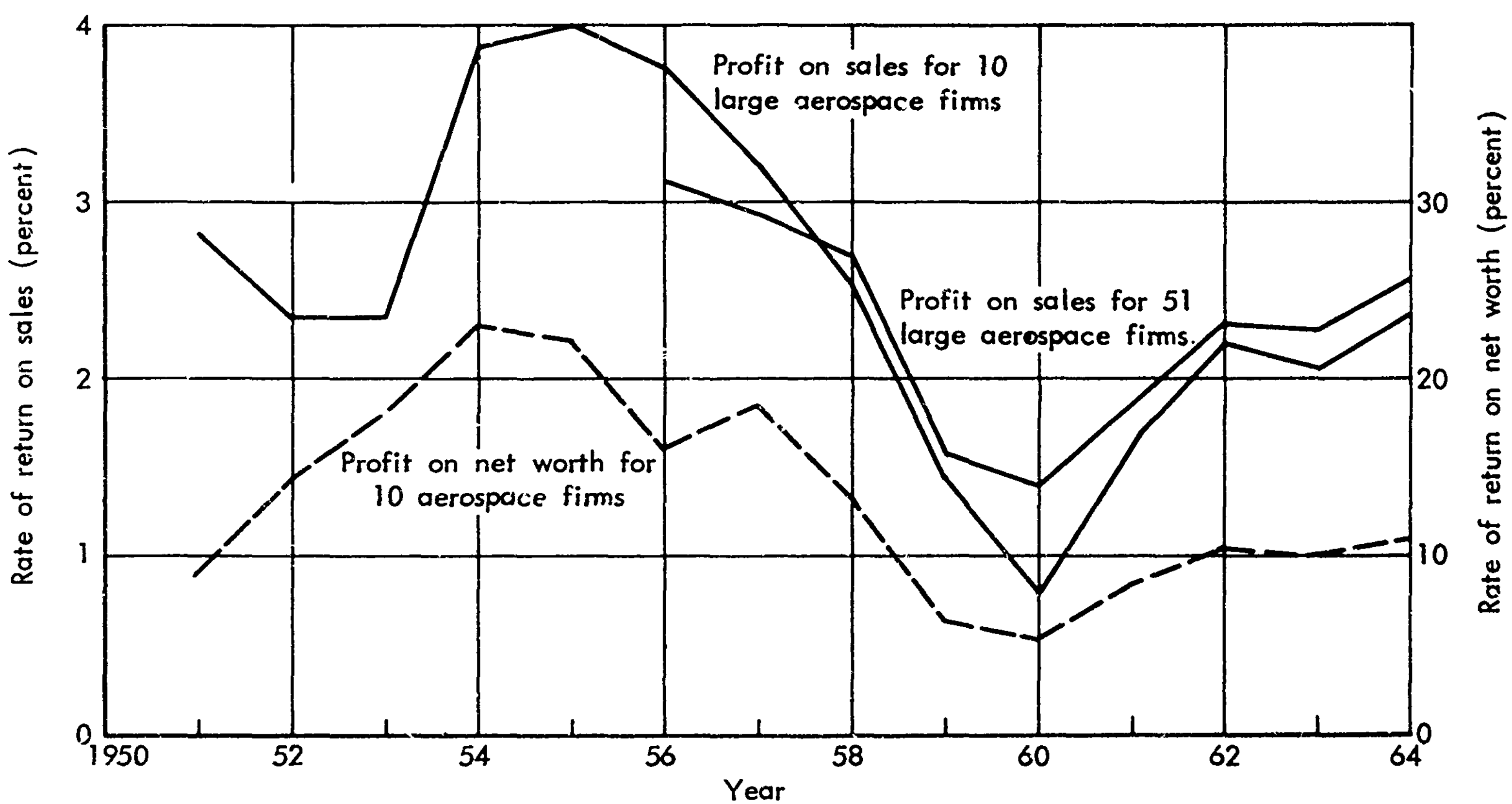

Fig. 1—Rate of return on net worth and sales: 1951-1964

To adjust for differences in firm size, profit is usually expressed as a percentage of some base. The choice of a base is significant. Those who support the view that aerospace profits are inadequate frequently use sales as the base, correctly pointing out that the aerospace rate of return on sales, as shown in Table 2, is relatively low.* Rate of return on sales is largely useless for economic analysis, however, since it provides no measure of the resources utilized to generate the profits. Some measure of inputs, such as assets or capital, is more meaningful. Table 2 shows the differences in ranking the various measures produce.**

Some industries maintain a consistent rank whether assets or net worth is used as the base, but others are erratic. The profits of the aerospace industry, for instance, rank tenth when measured either by sales or assets. Using these measures, the only lower group is food. By using net worth, however, the aerospace profit rate is the second highest, exceeded only by drugs. The drug industry group's profit rate ranks first measured either by assets or by net worth.

The differences in rank are due to differences both in financing and in asset turnover rates. In particular, capital turnover is much higher in aerospace than in most other industries. The last column

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*The firms included in the sample were selected from <u>Fortune</u>'s list of the 500 largest industrial firms. Among the many possible industry groups, eleven were selected for analysis. The choice was primarily governed by a desire to include a variety of different types of industries. At the same time, for statistical purposes it was important that each group contain a number of firms for which usable data series were available.

Once the groups had been chosen, firms were selected. For the aerospace group, the choice was made so as to include most of the large contractors of major weapon systems for which adequate data were available. For the other groups, the choice was made in order to get a reasonable number of firms but not so many that the sample would be biased. Also, effort was made to include middle-sized as well as very large firms in the sample. It would be valuable to compare the results for these 88 firms with a different and possibly larger sample. Data availability, however, seriously constrains sampling and replication. A list of the sample firms is contained in the Appendix.

**For discussion of the several possible measures, see Refs. 2 and 15 and Appendix G of Ref. 29.

Table 2

PERCENTAGE RATES OF RETURN IN 11 INDUSTRY GROUPS, 1957-1964[a]

Industry Group	Rate of Return on: Sales (%)	Rank	Assets (%)	Rank	Net Worth (%)	Rank	Average Capital Turnover Ratios[e]
Chemicals	11.4	1	9.8	2	14.0	4	1.2
Petroleum	9.9	2	8.1	4	11.4	7	1.1
Drugs	9.4	3	10.9	1	16.3	1	1.7
Office machines[b]	7.3	4	7.6	5	14.1	5	1.9
Automobiles[c]	6.5	5	9.6	3	14.7	3	2.2
Steel	6.3	6	5.5	9	8.4	10	1.3
Textiles	4.5	7	5.0	11	7.8	11	1.7
Electrical machinery[d]	4.4	8	6.5	7	11.9	6	2.7
Rubber	4.3	9	6.1	8	10.9	8	2.5
Aerospace	2.6	10	5.3	10	15.6	2	6.0
Food	2.3	11	6.7	6	10.7	9	4.7

[a]Profit after taxes. See Appendix A for a list of firms in each group.

[b]Includes computers.

[c]Includes truck and bus manufacturing.

[d]Includes electric appliances.

[e]Sales divided by net worth.

of Table 2 shows the turnover rates for net worth; the aerospace rate is 6.0, while the next largest, food, is 4.7, and the lowest, petroleum, is 1.1.*

The rate of return on net worth appears to be the most relevant concept for present purposes. We are concerned with whether the owners of aerospace firms and of other firms have received comparable compensation, allowances being made for risk. Consequently, a rate of return base reflecting stockholder's equity is appropriate. Net worth is such a measure and, therefore, is used in this study to compute the rates of return utilized in the statistical analysis.

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*See also the Stanford Research Institute's study [29].

COMPARABILITY VERSUS ADEQUACY

Most studies of aerospace profits have been concerned with the social appropriateness -- or adequacy -- of earnings [15, 16, 19]. This study is concerned with a related but significantly different concept, profit comparability.

Comparability requires that nominal profits be adjusted for interfirm or interindustry differences so that the adjusted profit rates reflect equal conditions with respect to one dimension of profit. Adequacy, a normative concept, requires that nominal profits be adjusted for comparability in all relevant dimensions and, additionally, that some norm be defined as a benchmark. It is much more difficult, of course, to attain comparability for all relevant variables and select a profit standard than it is merely to obtain comparability in one or more dimensions.*

Nominal or accounting profits have many functional and nonfunctional components or dimensions. Among these are returns to invested capital, payments for the labor contributions of nonsalaried owners, returns from innovations, rents reflecting the firm's ownership of scarce resources or its market power, risk premiums, and chance elements. To test fully whether profits in some industry were adequate, one would have to separate these functional and nonfunctional elements and then relate each functional element to the underlying managerial inputs that were rewarded. The result would be a set of profit rates completely adjusted for interfirm or interindustry differences in inputs and environmental situations. The next step would be to select some norm from among numerous alternatives. This choice is significant, for as Weston and Jacoby found [33], there are a number of defensible standards that yield disparate results for the aerospace industry.**

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*In fact, past studies of defense profits have short-cut the "ideal" procedure outlined here. The authors have made assumptions about the various components of profits, selected a standard, and made their judgments. The results are only as persuasive as the assumptions on which the short-cuts were based.

**Most studies of the adequacy of aerospace profits, like most studies of the adequacy of public utility profits, have focused on the return required to allow a firm access to capital markets. Therefore, corporate finance criteria have received the most attention.

The present study attempts no such ambitious task. Its more modest goal is to consider only one dimension of profits -- the component that reflects the firm's risk-exposure. In the sections that follow, nominal rates of return are adjusted to reflect differences in uncertainty. No attempt is made, however, to adjust these risk-compensated profit rates for other factors that influence the rate of return, nor to select any particular rate of return as a standard. The object of the statistical analysis is to enable us to make such statements as: "Allowing for risk, a profit rate of X percent in a given industry is equivalent to a profit rate of Y percent in some other industry." Whether X, Y, or some other rate is a socially optimal return is a question outside the frame of reference. It is therefore important to remember that no conclusion about the adequacy of profits can be drawn from these estimates of risk-adjusted rates of return.*

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*This point is reinforced by a statistical consideration. If the other factors that influence profits are not distributed randomly with respect to risk, then measurements of the relationship between risk and profits will contain the effects of the unspecified variable(s). For example, if the degree of market power possessed by firms were systematically related to risk, then our measure of risk premiums would include at least some part of the profit component stemming from differences in market structures. Consequently, unless one is certain that his model yields explicitly identifiable effects for all important causal factors it is extremely hazardous to draw normative judgments.

II. RISK AND THE RATE OF RETURN: THEORETICAL CONSIDERATIONS

THE MEANING OF RISK

Attempting to define risk can rapidly propel one into the higher realms of mathematics and philosophy. This is not the place for such an excursion, nor is it necessary to present proofs of all the basic theorems about economic behavior toward risk.* The two objectives of this section are much simpler. The first is to describe the concept of risk which is used. The second is to discuss how this measure relates to the theory of utility maximization, with particular reference to business firms.

In simplest terms, risk is defined as the inability to predict the outcome of a forthcoming event with close accuracy [23, 25]. This definition views entrepreneurs as making decisions in the face of uncertainty on the basis of probabilistic expectations about the outcomes of future events.** Certainty represents a situation where the entrepreneur's anticipations are sure to be fulfilled. Uncertainty is measured by the likelihood that the actual outcome will diverge from the anticipated.

Stated differently, the outcome of future events is assumed to be governed by a subjective probability distribution. If the entrepreneur views some specific outcome as having a probability of 1.0, he believes that event to be absolutely certain. All other cases are not certain,

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*For proofs of such theorems, see Refs. 3, 6, 8, 13, 21, 23, 25, 26, 28, and 32.

**Economic theory contains two basic approaches to this problem. In one, the decisionmaker balances the various moments of the probability distribution of potential outcomes on the basis of his utility function [21, 28]. In the other, the decisionmaker chooses among a set of claims to future returns. Each return is dated and each date is defined over the set of all possible states of the world [13, 14]. The present study is in the tradition of the first, or mean-variance, approach. The second, though the more thorough approach, is more elegant than the data at hand justify. However, Hirshleifer's complaint is well taken that users of the mean-variance approach should, but usually do not, explain how relative prices for "mean return" and "variability of returns" are established [13, p. 252].

and there is a probability distribution of possible outcomes. The characteristics of the uncertainty are measured by the moments of the probability distribution: variance, skewness, etc.*

To illustrate, consider Fig. 2. If an outcome has a probability distribution such as A, the forecaster is less subject to error than if he must predict a specific value from a distribution such as B. Curve C illustrates the limiting case of certainty; the probability of earnings equal to P' is 1.0. Thus, risk increases as the probability associated with a given range of outcomes around the expected value becomes smaller or, conversely, as the variance (i.e., the second moment, a measure of dispersion) of the distribution becomes greater. Consequently, a firm facing a distribution of potential earnings similar to B has greater risk-exposure than does a firm having a distribution such as A.

This definition of risk has many attractions. Most important are that it permits use of many standard economic theorems and, as will be seen, that it also permits statistical analysis. An implicit and important underlying assumption, nonetheless, is that the sets of profit-generating opportunities facing the firm in the present and all included future periods are determined exogenously. The firm can select among these opportunities on the basis of the mean expected earnings and higher moments, but it cannot affect the choice set. If this assumption holds, then reasonable conclusions about entrepreneurial attitudes and behavior toward risk can be drawn from examining the earnings distributions. On the other hand, the situation becomes much more complex if a firm can significantly influence the choice set. For example, it may be that by choosing, in the present period, a number of profit-opportunities having high expected returns and high variance, a firm could increase the mean and decrease the variance of future earnings. Perhaps it could do so by taking on a set of new and risky products that might secure for the firm a technological lead in some future period. In that case, if one were to pass judgment by looking only at the first

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*More precisely, risk can be identified with variability or dispersion if there is no time trend or serial correlation among residuals such that deviations can be predicted. This complication will be discussed later.

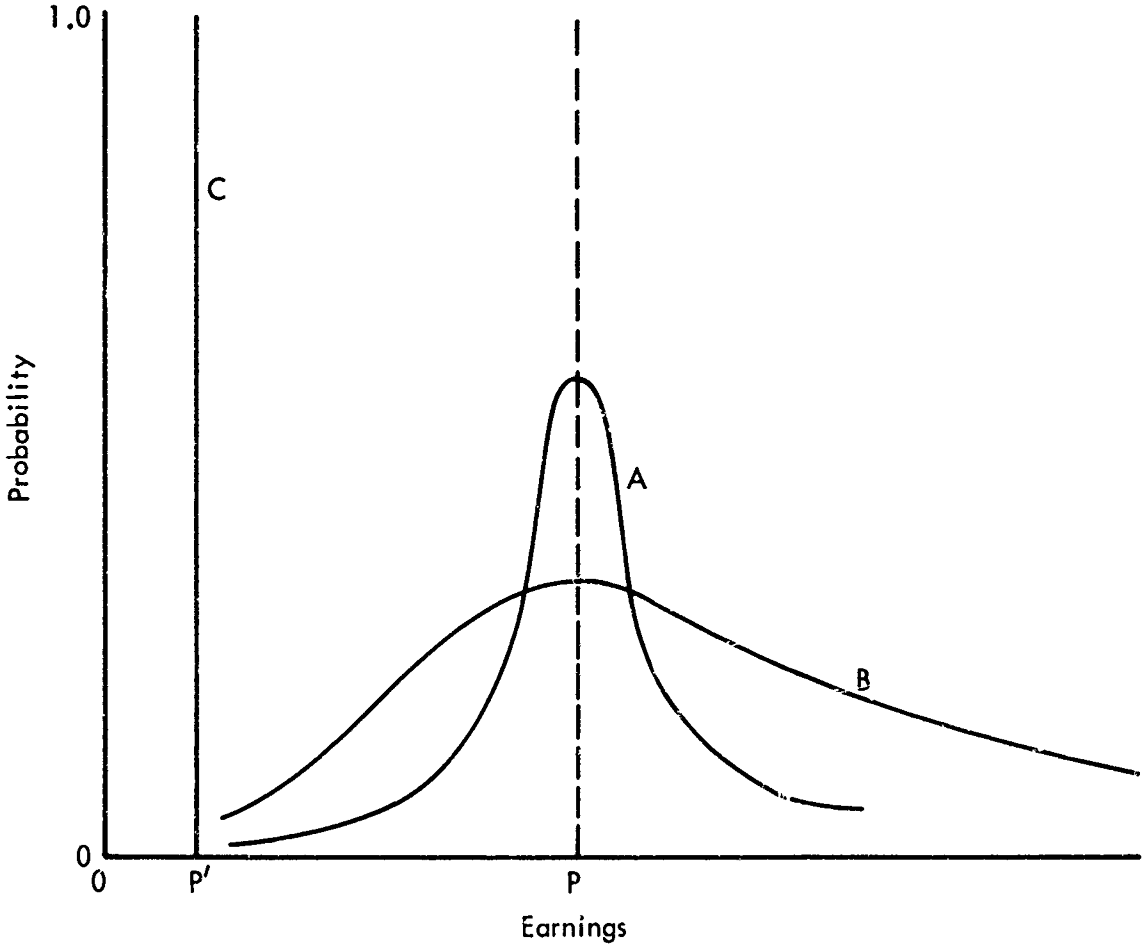

Fig. 2—Distributions of earnings

period, the firm would appear to have a predilection for risk situations. From a long run point of view, however, the firm would be seen as trying to avoid risk, not cultivate it.

Two comments about this possibility are in order. The first is that if such a policy were successful, the observed variance presumably would fall over time. Thus, concentrating on fairly long periods of time and on a number of firms should lessen the likelihood that this possible effect biases the statistical results.

The other point is more general. It may be that uncertainty is not measurable by the distribution of expected earnings, either because of the firm's ability to affect the choice set or for some other reason. It seems incumbent upon those who argue for a broader concept of uncertainty to be more specific about how this uncertainty is perceived by entrepreneurs than has been the case heretofore in the literature on profits. Consequently, we shall continue to identify risk with variability, though noting that there may be aspects of uncertainty not reflected in simple distributions of variables.

THE BASIS FOR A RISK PREMIUM

A firm interested only in maximizing profit would be indifferent between the alternatives A and B shown in Fig. 2. It is reasonable to assume, however, that differences in other characteristics of the distribution also affect rational choice. The customary approach is to view the decisionmaker as balancing expected return against other moments of the distribution, such as variance or skewness.

Most formal theorizing about decisionmaking under uncertainty has involved choices of: occupation [31]; assets to be included in an investor's portfolio [3, 28]; and investment projects [13, 14, 20]. Relatively few studies, however, have considered risk attitudes at the level of the firm and their influence on profit policies.[*]

The conventional theory of the firm abstracts from risk. Output, price, and investment decisions are governed by the intersection of the

[*]Three valuable studies of the theory of the firm under risk are Refs. 6, 23, and 25.

marginal cost and marginal revenue functions, since this maximizes profits. With risk present, however, it is not obvious that maximization of net revenue in this sense is the appropriate goal. Indeed, the standard propositions of elementary value theory hold only if the entrepreneur is indifferent toward risk or if the conventional marginal schedules reflect risk-discounted values.

One way to do this is to assume that firms maximize not profits, but expected utility.* Let U(P + W) be the firm's utility function.** Here utility is a function only of earnings, P (a random variable), and net worth, W. We are interested in the risk premium, R(P,W) required to make the entrepreneur indifferent between receiving the expected value of the uncertain return, P, and the certain amount, E(P + W) - R(P,W).*** If the utility function is concave, the firm is averse toward risk and R(P,W) > 0. This requires that U' > 0 and U'' < 0, or that

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*Fellner argues in favor of substituting, for the profit maximization assumption, the assumption of maximization of "risk taker's surplus" [6, pp. 173-174]. This latter concept weighs monetary returns by the risk-taker's utility function.

**Utility is introduced here to indicate that variables other than expected profits may enter into the firm's decision process; risk is one of the many possible factors that might affect the firm's choices. Whose utility function is to govern is a moot question, however. There are various candidates: managers, stockholders, some subgroup of either of these groups, the chief executive officer, and others [10]. It is assumed here that each entrepreneur (management) is interested in maximizing the expected utility of the net worth of the corporation on the basis of his judgments about stockholders' risk preferences. Such an assumption permits us to explore the relationship of uncertainty to rate of return without having to deal with the complexities of adding stockholders' utility functions or the Modigliani-Miller view that stockholders can lever portfolios to offset corporate management decisions about risk [22, 24].

Fellner, on the other hand, prefers to this assumption one that views the entrepreneur as acting on his own utility function, which includes as an argument gains that go to others. Fellner points out, however, that the concept of a utility function remains valid (and is unlikely to be linear), regardless of the separation of ownership from management or which of the two assumptions about entrepreneurial preferences is adopted [6, p. 173].

***P stands here for earnings in the sense of the change in net worth and not the rate of profit or profit per unit of time.

utility increase with earnings and net worth, but at a decreasing rate. On the other hand, if the firm prefers risk, $U(P + W)$ is convex and $R(P + W) < 0$ (a negative risk premium). The magnitude of the risk premium depends on net worth, W, and on the probability distribution of earnings, P.

Risk Aversion

Suppose a firm with net worth W is considering a risky investment that may result in earnings of P_1 with probability q, or earnings P_2 with probability $(1 - q)$. Expected ex post total net worth from the investment is

$$(1)\quad E(P + W) = [q(P_1) + (1 - q)\ P_2 + W] = q(P_1 + W) + (1 - q)(P_2 + W)$$

where W is the ex ante net worth. The expected utility of the investment is

$$(2)\qquad E(U) = qU(P_1 + W) + (1 - q)U(P_2 + W).$$

These values are shown in Fig. 3. Note that the expected utility of the investment is less than the utility of the expected earnings; or

$$(3)\qquad E(U) < U(E(P + W)),$$

where $E(U)$ is the expected utility to the firm of the uncertain earnings outcomes, and $U(E(P + W))$ is the utility to the firm of receiving earnings equal to the expected value, $E(P)$ [26].*

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*A proof of the theorem described here is simple for the two-point case. It must be shown that $E(U) < U(E(P + W))$. This is the same as proving that

$$[U(P_1 + W)q + U(P_2 + W)(1 - q)] < U[(P_1 + W)q + (P_2 + W)(1 - q)].$$

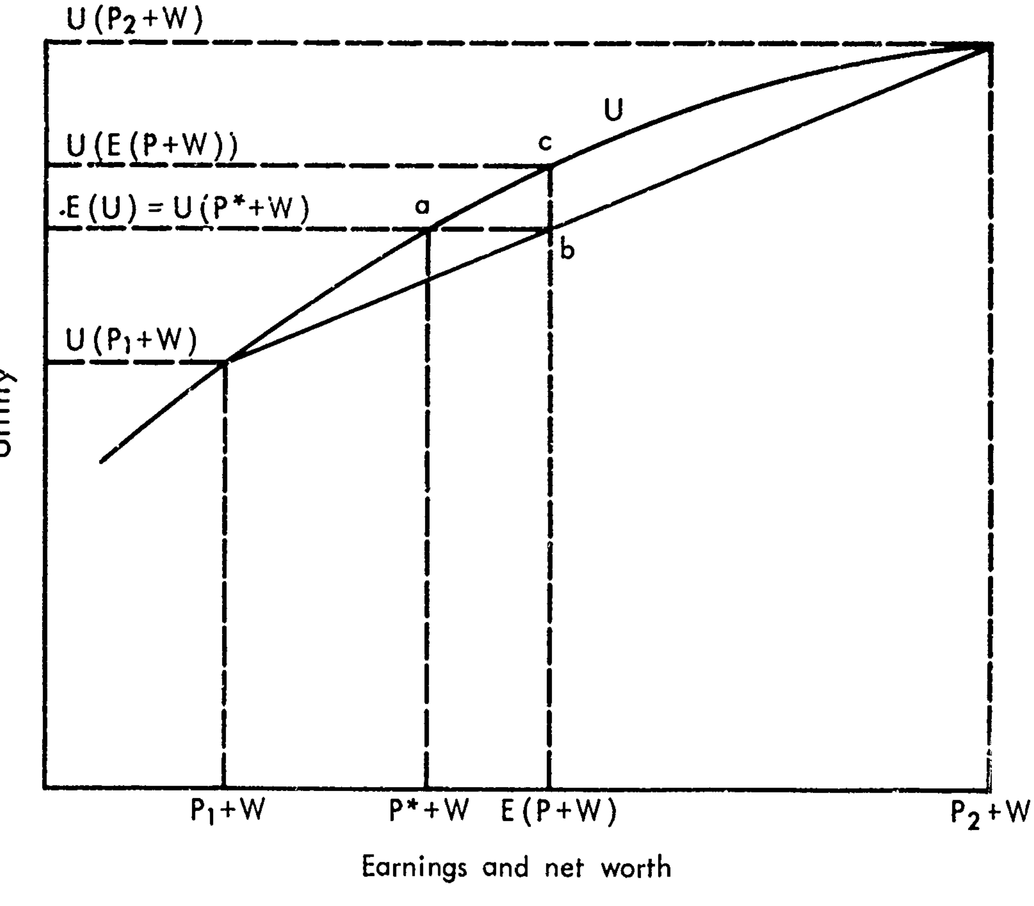

Fig. 3—Utility of earnings and net worth

Because the utility function is concave, the larger earnings outcome, P_2, is weighted less heavily than the smaller return, P_1, in the transformation from earnings to utility. As a result, the average utility of the weighted earnings outcomes is smaller than the utility that would result if the firm received earnings equal to the expected return from the investment. This implies that a risk-averse firm would be indifferent between the risky investment with expected earnings of E(P) and a risk-free alternative with earnings equal to P*, since both result in the same level of utility (expected utility of the risky investment, E(U) is equal to the utility of the certain outcome, U(P* + W)).

The difference between the investment's expected earnings, E(P), and the earnings that correspond to its expected utility, P*, can be interpreted as a risk premium -- that is, the amount of earnings necessary to make the firm indifferent between the risky investment with expected earnings E(P) and a riskless investment with certain earnings, P*. For the firm to undertake the risky investment, expected earnings must be greater by at least E(P) - P*; otherwise, the firm would forego the risky investment in favor of the relatively risk-free alternative

The difference in utility between an uncertain investment and its risk-free equivalent is

$$U(E(P + W)) - E(U(P + W)) = U(R(P,W)), \tag{4}$$

and U(R(P,W)) is the amount of utility necessary to compensate the firm for the increased risk of the uncertain investment. In Fig. 3, the risk premium corresponds to line segment ab, while the utility-equivalent of this premium corresponds to line segment bc.

Consider the chord shown in Fig. 3 connecting $[U(P_1 + W), (P_1 + W)]$ and $[U(P_2 + W), (P_2 + W)]$. The left-hand side of the inequality lies on this chord, since with q unspecified it is the equation for a straight line connecting these two points. The expected value, $q(P_1 + W) + (1 - q)(P_2 + W)$ lies somewhere between points $[U(P_1 + W), (P_1 + W)]$ and $[U(P_2 + W)]$. But since risk aversion has been assumed here, the utility curve is concave and is higher than the chord connecting these two points. Therefore, the inequality (3) holds.

In general, the shape of the utility function determines the effect of risk on the utility of outcomes. We have shown that for a concave utility function the firm is averse toward risk and requires a premium in the form of larger expected earnings to compensate for the risk of uncertain earnings.* For the more general case, however, the firm may be indifferent toward risk or even prefer risky investments to investments with certain outcomes.

Risk Neutrality

Suppose that the utility function is linear so that $U' = k$ and $U'' = 0$. In this case the firm is indifferent to risk and the risk premium is zero. As shown in Fig. 4(a), the expected utility of the risky investment with uncertain earnings alternatives P_1, P_2 is equal to the utility of the expected value, or

$$E(U) = U(E(P + W)) \tag{5}$$

and the risk premium is zero since $E(P) = P*$. Because risk has no effect on the firm's investment decisions, utility maximization and profit maximization are equivalent. Consequently, the firm would be indifferent between a risky investment and a risk-free investment so long as expected earnings were identical.**

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*Concave indifference functions imply risk aversion but the shape of the utility function does not, of course, depend upon risk aversion. For a discussion see Ref. 26, and also p. 119 of Ref. 6.

**For the two-point case illustrated in Fig. 4(a), a proof of the equality of E(U) and U(E(P + W)) is simple. Since the utility function is linear, it can be written as

$$U(P + W) = a + b(P + W) \tag{i}$$

and utility of expected earnings is

$$U(E(P + W)) = q[a + b(P_1 + W)] + (1 - q)[a + b(P_2 + W)] \tag{ii}$$

On the other hand, expected utility is

$$E(U(P + W)) = qU(P_1 + W) + (1 - q)\ U(P_2 + W) \tag{iii}$$

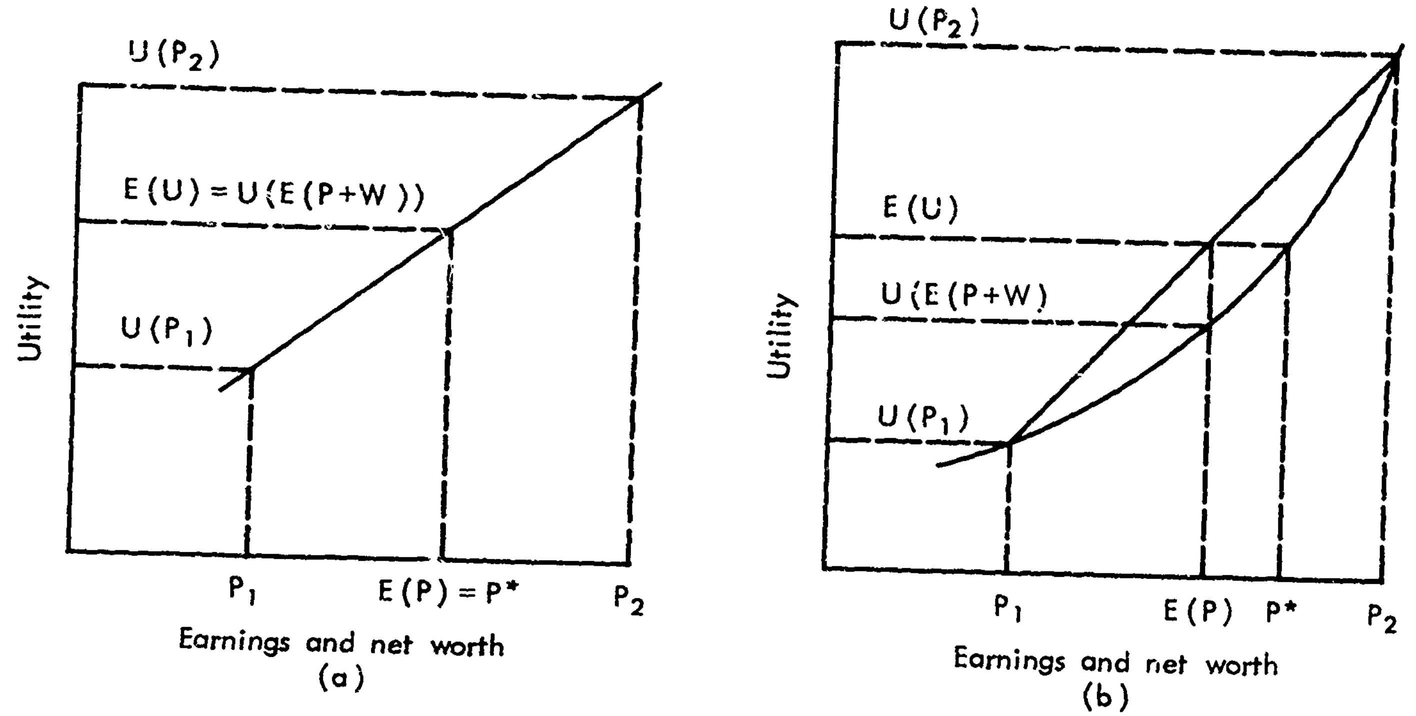

Fig. 4—Risk neutrality and risk preference

Risk Preference

Now suppose the utility function is convex, as shown in Fig. 4(b), so that $U' > 0$ and $U'' > 0$. Here, increments of earnings increase the firm's utility by an increasing amount. In this case, the expected utility of the uncertain earnings exceeds that of expected earnings, so that

$$E(U) > U(E(P + W)), \tag{6}$$

and the firm would be indifferent between the risky investment and one with certain but higher earnings of P^*. The risk premium is negative; the firm would be willing to pay a premium in the form of smaller expected earnings to obtain the risky investment. This premium is

$$P^* - E(P). \tag{7}$$

Because the utility function is convex, the larger earnings outlay, P_2, is weighted more heavily than the smaller outcome, P_1, so that the expected utility to the firm exceeds the utility of the expected earnings from the investment. Consequently, the risky investment is more valuable to the firm than a risk-free alternative.**

We make no assumption about which of these possibilities best describes the firm's attitude toward risk. In the statistical analysis that follows, the signs of the coefficients in the relationship between rate of return and risk will indicate whether the firms in the sample were on average risk-averse, risk-neutral, or risk-preferential.

---

or

$$E(U(P + W) = q[a + b(P_1 + W)] + (1 - q)[a + b(P_2 + W)] \tag{iv}$$

so that

$$E(U((P + W)) = U(E(P + W)). \tag{v}$$

**The proof of this parallels that given previously for the risk-aversion case.

THE RISK PREMIUM AND THE DISTRIBUTION OF EARNINGS

We are not concerned with earnings distributions or utility functions per se, but with the risk premiums or risk components of corporate earnings. The subject of interest is the interaction between the probabilities of earnings and the utility function. We shall show how this interaction determines the risk component of profits for risk-averse firms. The appropriate revisions for risk neutrality or risk preference will be apparent.

The effect that changes in the probability distribution have on expected utility and on the risk premium can be illustrated graphically. Suppose that both the probability distribution of potential earnings and the firm's utility function are known, as in Fig. 5(b). Suppose that the probability distribution is that shown as curve (1). Then it is not difficult to derive both the probability distribution of utility, shown as curve (1) in Fig. 5(a), and its expected value, $E(U_1)$. Note, however, that while the probability distribution of earnings is symmetric about the expected value, E(P), the distribution of utilities is skewed to the left. This occurs because the utility function is concave, resulting in a nonlinear transformation from earnings into utility. The expected value of the utility distribution, $E(U_1)$, is less than the utility of the expected earnings, U(E(P + W), and the difference, translated back into monetary terms, is the risk premium, E(P) - P*.

Now suppose that the probability distribution of earnings is not curve (1), but curve (2). Again, this distribution is symmetric about the same expected value, E(P), but the dispersion is much greater. In this case the probability of earnings equal to the expected value plus or minus a given amount is smaller, and the probabilities attached with earnings outside this range are larger. Risk exposure with curve (2) is greater and the risk premium should be larger.*

The probability distribution of utilities in this case is curve (2) in Fig. 5(a) and, as before, it is not symmetric about its expected value. The important point, however, is that the expected utility, $E(U_2)$, is less than the expected utility in the first case, $E(U_1)$. In

*See footnote on p. 22 for a proof of this theorem.

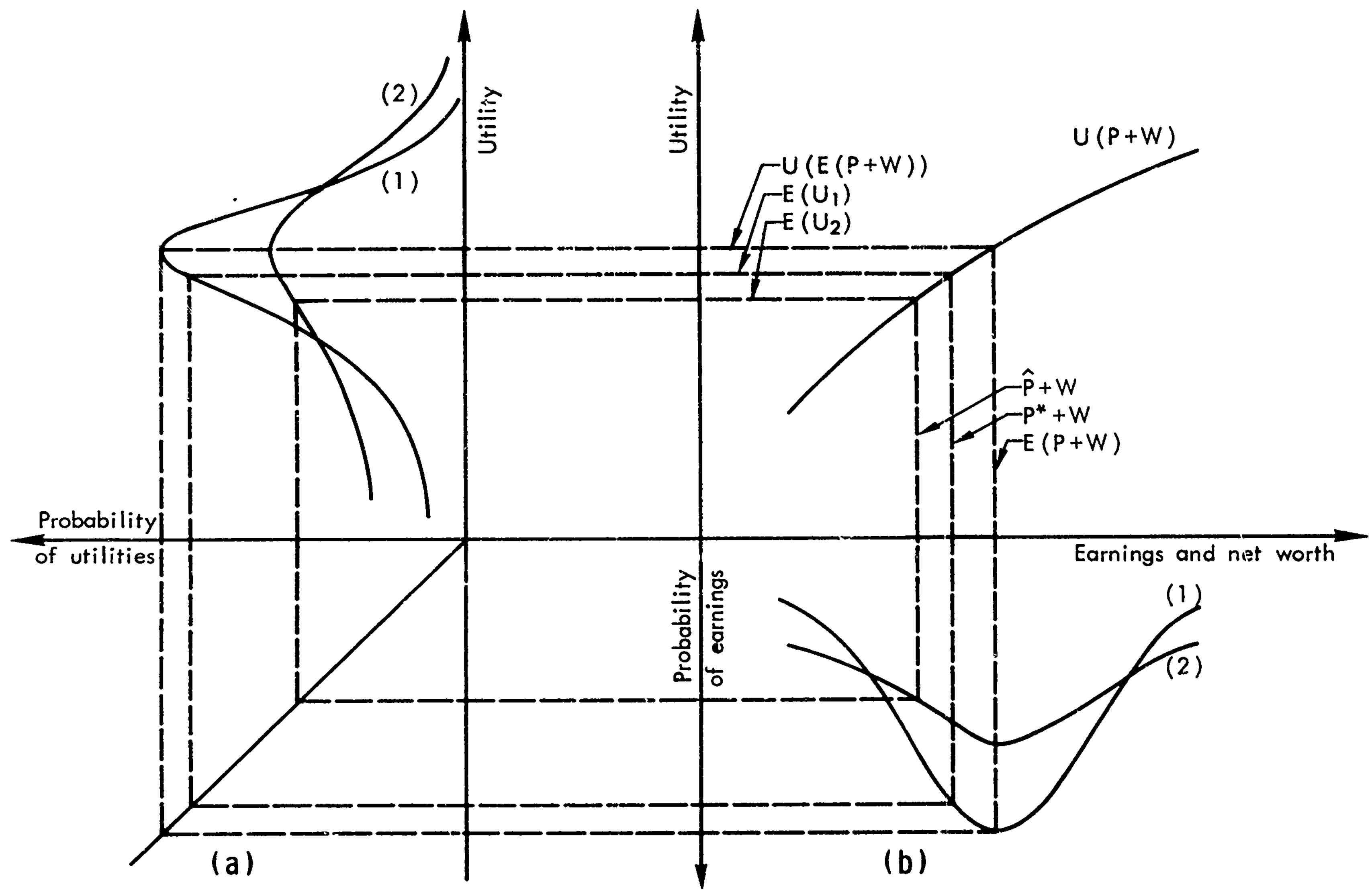

Fig. 5—Effect of dispersion on risk premium

other words, expected utility has declined as a result of the increased dispersion of the probability distribution of earnings. As a result, the risk premium has become larger, so that

$$(8) \qquad (E(P) - \hat{P}) > (E(P) - P^*).$$

Fig. 5 illustrates that greater variance in the probability distribution of earnings implies greater risk and, for a risk-averse firm, leads to a larger risk premium. This suggests that earnings should be larger, on the average, for firms with greater variation in their earnings than for firms with little earnings variability.

Dispersion is not the only characteristic of the probability distribution of earnings that affects the risk premium; skewness may also have an important effect [3, 12, 31]. For example, management may prefer a distribution of earnings that is skewed positively, rather than a symmetric distribution, because the probability of extremely low earnings is small. The firm may be willing to accept smaller average earnings in this situation than if the distribution were symmetric about the same mean expected values.

This is illustrated in Fig. 6. In 6(b), both probability distributions of earnings have the same expected value. However, while curve (1) is symmetric, curve (2) is skewed to the right. This distribution has been constructed so that the resulting distribution of utilities (shown as curve (2) in (a)) is symmetric about its expected value. In this example, skewness offsets the dispersion so that the risk premium is zero; i.e., $E(P) - \hat{P} = 0$ and $E(U) = U(E(P + W))$. Positive skewness results in smaller risk exposure, while negative skewness leads to greater risk exposure.* The implication is that

*In order to show that variance, skewness, and higher moments of the distribution also have an effect on the risk premium, expand $U(P + W)$ in a Taylor series about $(\hat{P} + W) = E(P + W)$,

$$(i) \quad U(P + W) = U(\hat{P} + W) + U'(\hat{P} + W)(P - \hat{P}) + \frac{U''}{2!}(\hat{P} + U)(P - \hat{P})^2 + \frac{U'''}{3!}(\hat{P} + W)(P - \hat{P})^3 + \text{higher order terms.}$$

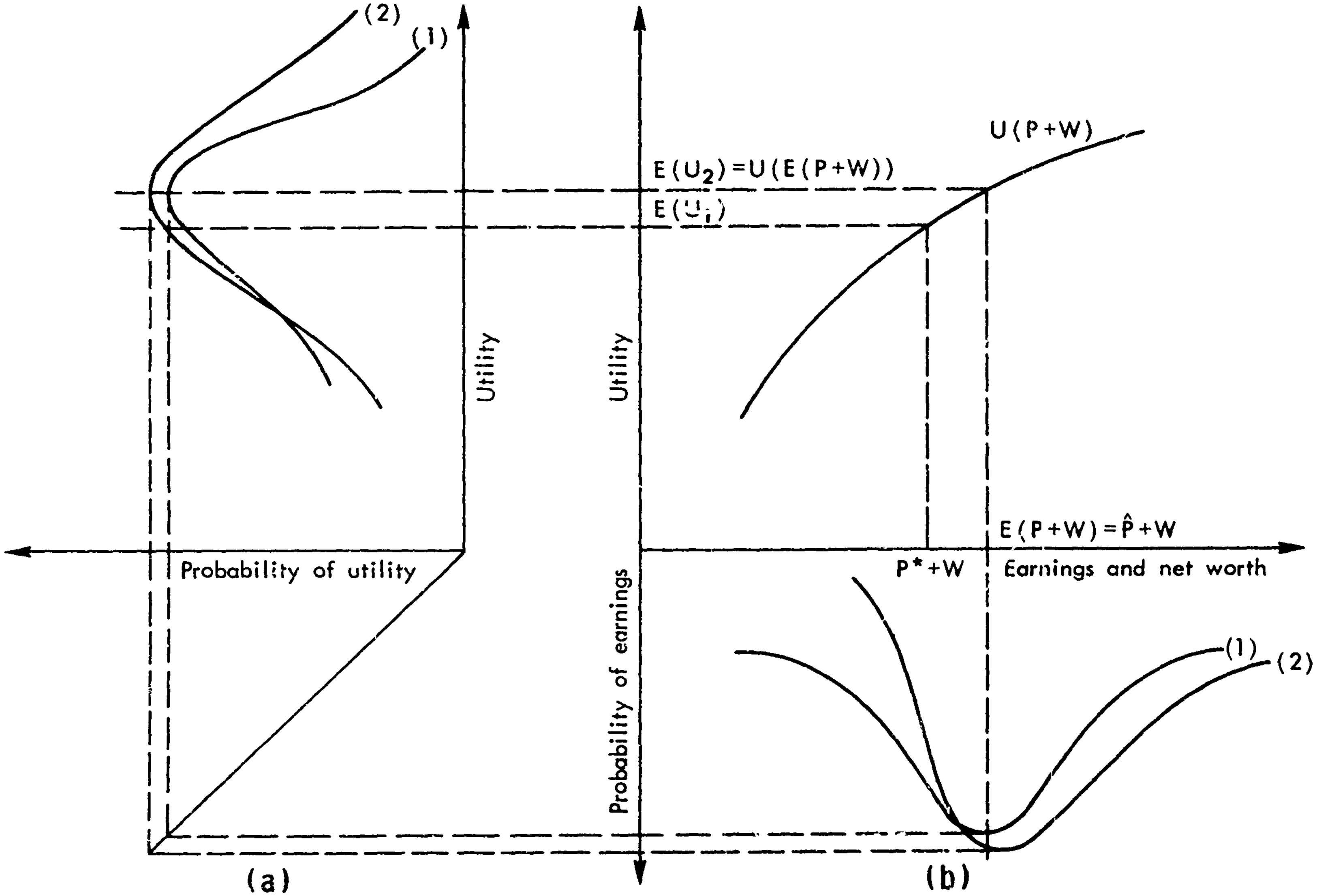

Fig. 6—Effect of skewness on risk premium

earnings should be smaller, on the average, for firms having earnings distributions that are skewed to the right, and vice versa.

These results suggest that once the form of the utility function is specified, risk exposure depends on characteristics of the probability distribution of earnings. The required risk premium becomes larger as the spread of the earnings distribution increases, but decreases as the distribution becomes positively skewed. The firm's risk exposure as defined here can be measured by observing characteristics of its earnings distribution.

RISK AND PROFIT EQUILIBRIUM

Before testing the hypothesis that earnings are larger for firms with greater risk exposure, one link in the discussion of the relationship between risk and earnings remains to be completed. This missing link is the mechanism by which entrepreneurial preferences for risk and profits are translated into industry profit differentials or risk premiums and discounts.

Conventional economic theory implies that, with well-functioning capital markets, the equilibrium rate of return on risk-free investment

---

Taking expected values and holding W, $\hat{P}$ constant,

$$\text{(ii)} \quad E[U(P + W)] = U(\hat{P} + W) + \sigma_p^2 \frac{U''}{2!}(\hat{P} + W) + \sigma_p^3 \frac{U'''}{3!}(\hat{P} + W)$$
$$+ \text{ higher order terms.}$$

Rearranging terms, the differences between expected utility and utility of expected earnings is

$$\text{(iii)} \quad U(\hat{P} + W) - E[U(P + W)] = -\left[\frac{1}{2!}\sigma_p^2 U''(\hat{P} + W) + \frac{1}{3!}\sigma_p^3 U'''(\hat{P} + W) + \text{ higher order terms}\right].$$

The left-hand side of (iii) is the risk premium, R(P,W), and it becomes apparent that the second, third, and higher moments all may affect the magnitude of the risk premium.

Since $U'' < 0$ for concave utility functions, the risk premium must increase with larger variances. However, it is not clear whether U''' is positive or negative. If we assume that firms enjoy positive skewness ("long shots"), $U''' > 0$ and the risk premium becomes smaller as skewness increases. Consequently, skewness could offset or even outweigh the variance effect, depending on the shape of U.

will be identical among all activities. Entrepreneurs seek investments yielding the largest rates of return. Consequently, as capital is withdrawn from less profitable activities, the rates of return for these activities will rise. Similarly, the inflow of capital into higher-yield investments will force the rate of return in these activities downward. Equilibrium occurs when the rates of return on investment are identical among all activities.

When risk is considered, the adjustment process is more complex. Because risk exposure varies among alternative investments, entrepreneurs balance risk against expected rates of return. Consequently, capital is transferred from low-return high-risk activities to high-return low-risk investments until equilibrium is reached. This equilibrium is characterized by a set of equilibrium risk premiums reflecting differences in risk exposure. In this situation risk-adjusted rates of return would be equal among alternative investments, but observed rates of return would differ by the amount of the risk differentials.

In short, we posit that capital markets respond to risk just as they respond to expected rates of return. We should therefore expect to find a structure of risk-adjusted rates of return that motivate or discourage investment. That is, part of the earnings differentials that are observed among alternative investments can be attributed to risk; these are the risk premiums that compensate for differences in risk-exposure. Two questions then become relevant: whether these risk premiums can be measured, and whether the relationship between the rate of return and risk implied by economic theory can be identified. The following sections consider these issues.

III. RISK AND THE RATE OF RETURN: EMPIRICAL RESULTS

THE MEASUREMENT OF RISK

Considering the importance of risk in profit theory, and the extensive theoretical literature identifying risk with dispersion, there is a surprising paucity of statistical investigations. One can only speculate, but there are two possible reasons for this neglect. One relates to policy-uses of such investigations, the other to the required theoretical assumptions.

To consider the policy issue first: risk premiums have only theoretical interest except in regulatory situations. When competition prevails and there is free entry into and out of industries, profit rate components lose much of their policy significance. Put differently, in the unregulated sector of the economy, profit rate policy properly focuses on preserving competition to assure that realized profits are appropriate. In regulatory situations, on the other hand, profits are set as an ex ante component of price. Consequently, regulators and regulated firms have more interest in trying to analyze the functional comparability of the allowed profits with profits of other firms and industries.* Economists have generally been more concerned with the economics of competition than with the economics of regulation. This may explain the lack of statistical studies of risk.

The regulatory implications of risk premiums are particularly relevant for this study. The prices of many sales of aerospace products are negotiated rather than set competitively. There is a practical significance, therefore, to asking whether the profit rate of this group of firms is comparable to that of other industry groups with respect to relative risk exposures. Thus, this study gives special attention to the aerospace rate of return.

The second reason for the limited number of statistical studies of risk and profits may be the problem of dealing with expectations. Risk is regarded here as the likelihood that the actual outcome of

*For a discussion of the judicial position of risk comparability see Ref. 4.

some event will differ from that anticipated. The difficulty is that it is impossible to observe anticipations. As will be discussed shortly, this problem can be overcome if one is prepared to use a proxy for the expected rate of return; nonetheless, the assumption required to handle anticipations may well have discouraged empirical investigation.

Two important exceptions to the above remarks about the shortage of investigations must be considered.* The first is Stigler's attempt to measure risk premiums [30]. Stigler's investigation of risk premiums was made in connection with his wide-ranging study of rates of return and investment in manufacturing industries. The basic data were rates of return on assets for companies in unconcentrated manufacturing industries reporting to the Internal Revenue Service.

With respect to the influence of risk on the rate of return, Stigler estimated the relationship between average rate of return and standard deviation for two periods, 1938-1947 and 1947-1954. His results were:

(9) <u>1938-1947</u>

$$R = 8.44 - .231\sigma \qquad r = -.151 \ (n = 38)$$

<u>1947-1954</u>

$$R = 6.31 + .302\sigma \qquad r = .165 \ (n = 54)$$

Not only were the coefficients statistically insignificant, but the signs (which indicate risk aversion and risk preference, respectively) differed in the two periods. Stigler concluded that:

> These two measures of risk are so crude that we are not entitled to conclude that no risk premiums are demanded. All that can be concluded is that we find no evidence of such premiums in our own restricted investigation [30, p. 64].

A second important study of risk and profits is Cootner and Holland's pioneering work [4]. This study utilized data for about

*The studies of aerospace profit-adequacy [15, 16, 19] might also be thought of as exceptions. However, as discussed previously, the objective of these studies differs significantly from that of studies of risk-comparable profits.

100 firms in 39 industries for the period 1946-1960.* In contrast to Stigler's study, Cootner and Holland found a significant relationship between risk and earnings.

Cootner and Holland use two models. The first is a simple linear one, $I = ax_1 + b$, where I is the industry average rate of return and x_1 is the standard deviation of company rates of return around the unweighted industry average.** The empirical results, shown in Eq. 11, were statistically significant and indicated a high positive relationship between rate of return and risk.

$$\text{(11)} \qquad I = \underset{(.230)}{.935}x_1 + 8.18 \qquad R = .550$$

The authors offered the following economic rationale for this model:

> If we assume that an entrepreneur entering an industry is purchasing a proportionate share of the experience of every firm in the industry then it would seem that the dispersion of company rates of return around the average rate of return of the industry to which they belong is an indication of the riskiness of an investment in that industry. Since the standard deviation of such rates of return indicates to an investor the likelihood that he would fare differently from the industry average, we would expect that if executives were risk-averters large standard deviations would require high average rates of return to attract investment [4, p. 4].

The second Cootner-Holland model [4, pp. 7-8] seeks to explain company rates of return rather than industry rates. It is of the form:

$$\text{(12)} \qquad Y = a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + c$$

---

*Cootner and Holland did not use data for the aircraft manufacturing industry in their regressions, since ". . . its rate of return and the dispersion thereof were approximately determined by the federal government, not by 'market factors'" [4, p. 55].

**Cootner and Holland explored the effect of using weighted averages in their models, but found no significant differences among the results [4, p. 53].

where Y = average rate of return on capitalization for a company for the postwar period, 1946-1960.

x_1 = standard deviation of the company's rates of return over the postwar period around the mean of the industry to which the company belongs for the same period.

x_2 = standard deviation of the annual rates of return for the company around its postwar average.

x_3 = skewness of the company's annual rates of return.

x_4 = standard deviation of annual changes in the company's rate of return around the mean postwar change.

In this second model, company rates of return were related to four measures of uncertainty. Only two of these measures were statistically significant, however: the standard deviation of the company's rates of return about the industry average, x_1, and the standard deviation of the firm's annual rates of return about its own average. Neither skewness nor the standard deviation of changes in rates of return about the average change were significant. The final formulation was

$$Y = \underset{(.157)}{0.788x_1} + \underset{(.115)}{0.944x_2} + \underset{(.203)}{5.31} \qquad R = .50 \tag{13}$$

For present purposes, the Cootner and Holland methodology is more important than their results. Note the difference between their two models, Eqs. (11) and (13). In the first, variance is measured by the dispersion of company rates of return from the industry mean. In the second model, this same measure is used with the addition of another measure -- the deviation of annual rates of return for each firm about its own mean. The logic for measuring variance differs sharply between these two methods, however. We believe it is more appropriate in studies of risk to measure uncertainty by deviations of the firm's rates of return about its own mean rather than about the industry mean.

There are several reasons for this preference. First, intraindustry dispersion does not measure the variability of profit but merely

indicates the extent to which individual firm rates of return differ from one another within the industry. This measure of risk could be identical for two different industries even though the firms' rates of return in one were very stable while those in the other were extremely erratic. Although the risk exposure facing the firms in these two industries would be different, this measure of dispersion could indicate the same level of risk for both industries.

We can illustrate the point by comparing the risk exposure in two industries, each consisting of two firms with hypothetical earnings patterns shown in Table 3. There is no variability in the earnings of either firm in Industry I. Even though the spread between the average rates of return for these firms is large (intraindustry dispersion), there is little uncertainty about each firm's annual earnings.

Table 3

ANNUAL RATES OF RETURN FOR TWO HYPOTHETICAL INDUSTRIES
(In percent)

	Industry I		Industry II	
Year	Firm 1	Firm 2	Firm 1	Firm 2
1	6	14	5	7
2	6	14	14	13
3	6	14	7	14
4	6	14	13	6
5	6	14	6	5
6	6	14	14	15
Average	6	14	10	10
Industry average 10%			Industry average 10%	
Standard deviation . . 4.2%			Standard deviation . . . 4.2%	

The earnings for the firms in Industry II vary considerably, and although intraindustry dispersion is the same as for Industry I, there is a good deal more variability in the earnings of these firms in any given year. The risk level for firms in this industry would seem to be much greater than that in Industry I, even though the standard deviation

of the firm's rates of return about the industry average is identical for both industries. For this reason, it is desirable to seek dispersion measures that reflect the variability of individual firm earnings.

A more serious difficulty with this measure involves the concept of industry risk implied by computing deviations from the industry mean. It can be argued that this is meaningful only for homogeneous industries -- industries in which all firms produce similar products, compete in the same markets and, in general, face the same elements of risk and uncertainty. In this situation, the risk exposure for one firm would be identical to that for any other in the industry, and industry risk exposure would be synonymous with risk exposure for the individual firm.

It is not easy to think of industries that meet these requirements, especially when the industry classifications are broadly defined. None of the industries considered in this study are homogeneous. As a result, although the earnings of the individual firms in these industries are influenced to some extent by common elements of risk, they are also influenced significantly by unique elements of uncertainty caused by characteristics of the individual firm.

Thus, the intraindustry measure does not fully agree with a reasonable theoretical notion of risk. Intraindustry dispersion measures the <u>spread</u> of firm rates of return about the industry average over time rather than the temporal <u>stability</u> of either firm or industry earnings. It was argued in Sec. II that risk depends on the ability to predict future earnings. This forecasting ability was equated with earnings stability, since the more temporally stable earnings are, the easier they are to forecast. Intraindustry dispersion would measure this type of uncertainty only if there were no autocorrelation in the deviations of particular firms from the industry average over time. In fact, however, these deviations are highly autocorrelated for many firms. Thus, intraindustry dispersion is not a suitable measure of risk, as defined here.

Intraindustry dispersion, as Cootner and Holland point out, however, measures risk in another sense. Imagine an entrepreneur considering entering an industry and, therefore, trying to predict his potential

profits. One way to do this is to examine the rates of return of the existing firms. If these are very similar, the uncertainty associated with his estimate will be much less than if the firms have widely dispersed rates of return. Intraindustry dispersion thus can be thought of as a measure of the risk of entry, as Cootner and Holland agree. Even so, intraindustry dispersion measures the risk of entry only in a specialized situation. This is where entry is into a broad industry and no knowledge exists concerning the explanation of interfirm differences in profit rates. Only in this case will intraindustry dispersion be the entering entrepreneur's best risk estimate.

For a firm already in some line of commerce, intraindustry dispersion is not a good measure of risk. If the industry group has diverse but temporally stable rates of return, the firm's own history will provide a better basis for measuring its risk exposure. If the rates of the group members are similar, presumably the firm will be concerned not with how well it is going to do relative to its rival, but with how stable its future profits will be.

For all these reasons we have chosen to use, for the statistical analysis, a definition of risk that is based on the deviation of company rates of return from their own mean. Nonetheless, because of the seminal importance of the Cootner-Holland work, and in order to permit a comparison of the differences in empirical estimates produced by using their approach instead of our approach, we have also analyzed our data using an intraindustry dispersion measure. This measure is

$$(14) \qquad \sigma_j = \left[\frac{\sum_{t=1}^{n} \sum_{i=1}^{m} (r_{it} - R_j)^2}{nm - 1} \right]^{\frac{1}{2}}$$

where σ_j = standard deviation of firm rates of return about the industry average, industry j;

R_j = average rate of return on net worth in industry j;*

r_{it} = rate of return of firm i during year t;

n = number of years in sample;

m = number of firms in industry.

The relationship between the mean rate of return and standard deviation computed in this fashion is shown in Fig. 7. Average earnings are correlated with intraindustry dispersion. Note particularly that the drug, aerospace, automobile, and office machine groups have the highest rates of return as well as the largest standard deviations. At the other end of the scale are steel, textile, rubber, and petroleum with low rates of return and small standard deviations.

The results shown in Fig. 7 can be expressed as

$$R_j = R_0 + b\sigma_j \tag{15}$$

where R_j = average rate of return for industry j during the period;

R_0 = intercept;

σ_j = standard deviation of annual firm rates of return about the industry average;

b = marginal effect of dispersion on average rates of return among all industries.

Estimates of these terms for the eleven industries included in the sample are:

$$R_j = 6.979 + \underset{(.223)}{1.084\sigma_j} \qquad R^2 = .734 \tag{16}$$

---

*R_j is not weighted by the size of the firm. We are not interested in the average ability of the industry to forecast but in the ability of each firm to forecast its own earnings. Consequently, each firm's profit rate is treated the same way regardless of the magnitude of the earnings involved.

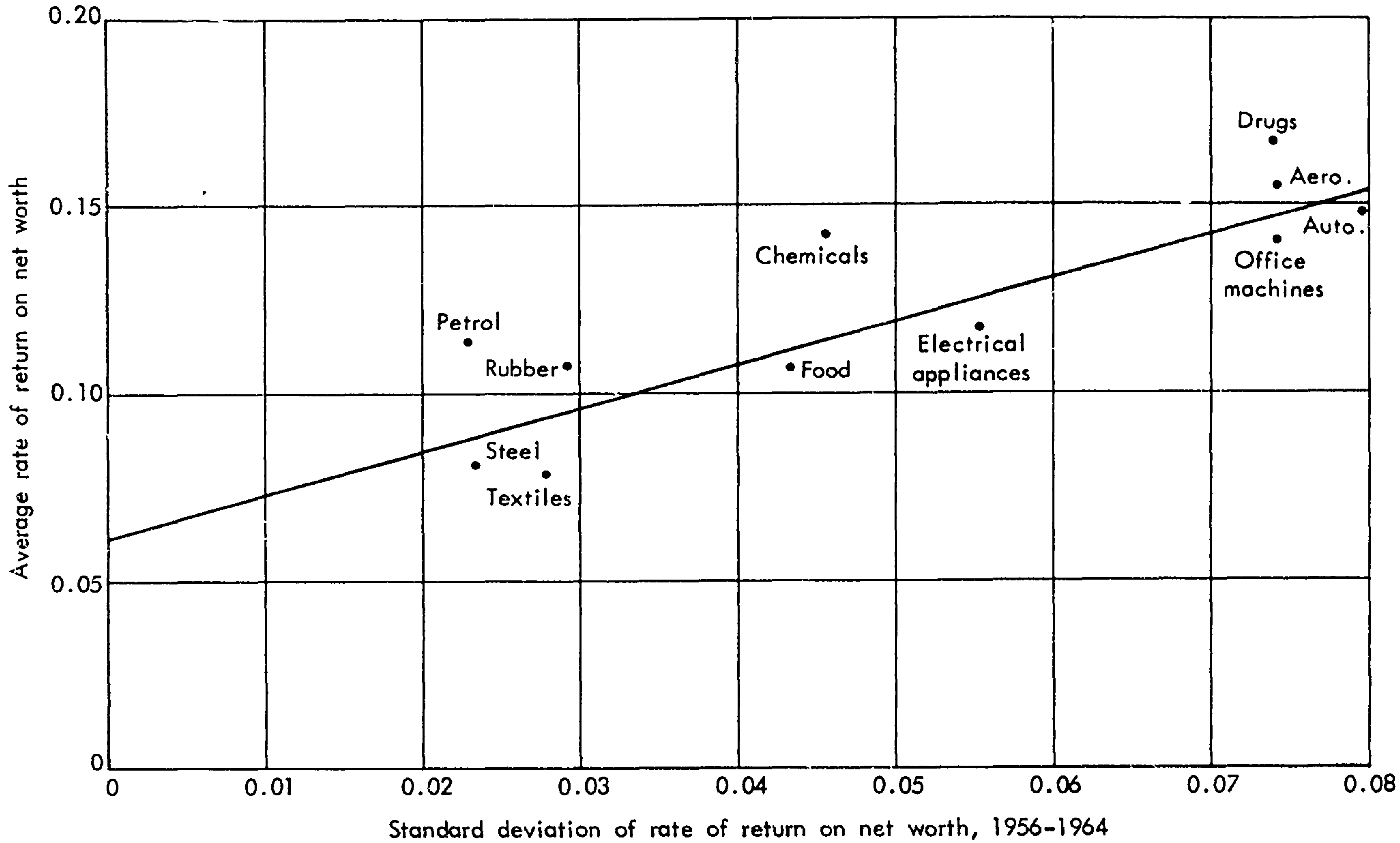

Fig. 7—Rate of return and standard deviation (Intra-industry dispersion): eleven industry groups, 1956-1964

The value of the coefficient, b, indicates that the average industry rate of return increased 1.08 percentage points for each increase of 1 percentage point in the standard deviation. (This result is statistically significant at the 0.01 level of probability.) The value of R^2 indicates that about 73 percent of the variance among industry average rates of return is explained by the variance in the standard deviation of individual firm rates of return about their respective industry averages.

The intercept, R_0, implies that the expected rate of return in an industry with no dispersion among individual firms would be 6.9 percent. It is tempting to interpret this as a "risk-free" rate of return but since no industry is without risk, the intercept coefficient is really an extrapolation from risky situations rather than a measure of the risk-free rate of return. More important, the intercept is the repository for all the influences on profits not encompassed in the risk variables. Therefore, this intercept cannot appropriately be regarded as a risk-free rate of return in the sense that yields on government bonds are frequently interpreted as risk-free yields. We shall refer to R_0 as the "risk-adjusted" rate of return. By this we mean that it is the rate of return that would be expected after allowing for the influence of variability of earnings. Risk-adjusted rates of return, then, in our terminology, include a variety of profit determinants.

The expected rate of return for any industry can be predicted from this relationship by computing the industry risk differential, $b\sigma_j$, and combining this component with the overall risk-adjusted rate of return, R_0. In addition, a risk-adjusted rate of return for each industry can also be computed from

$$\hat{R}_j = R_j - b\sigma_j, \tag{17}$$

where $\hat{R}_j$ = average risk-adjusted rate of return for industry j.

The average risk-premium and the risk-adjusted rate of return defined in Eq. (17) are shown in Table 4 for each industry. The first

column contains the average unadjusted rates of return on net worth; the second and third columns contain the risk-adjusted rates of return, $\hat{R}_j$, and the risk-differentials, $b\sigma_j$, respectively.

The risk differentials for these industries are substantial; adjusting industry earnings in this manner results in risk-adjusted rates of return that are much lower than the unadjusted rates. It also appears that the spread among these adjusted rates is smaller than that for the unadjusted figures. The risk-adjusted rates of return still

Table 4

RATES OF RETURN FOR 11 INDUSTRY GROUPS, 1956-1964, ADJUSTED FOR INTRAINDUSTRY DISPERSION

Industry	Rate of Return		Risk Premium
	Unadjusted	Adjusted	
Drugs	.1632	.0842	.0790
Aerospace	.1560	.0752	.0808
Automobiles	.1477	.0619	.0858
Chemicals	.1409	.0911	.0482
Office machines	.1408	.0605	.0803
Electrical machinery	.1195	.0596	.0509
Petroleum	.1147	.0898	.0249
Rubber	.1096	.0791	.0305
Food	.1072	.0604	.0468
Steel	.0825	.0566	.0259
Textiles	.0789	.0487	.0302

differ significantly among industries; this is no doubt due to the effects of other profit components that have not been taken into consideration, such as market structure, technological change, investment, and differences in managerial efficiencies.

THE COMPANY-MEAN STANDARD-DEVIATION APPROACH

The dispersion measure we prefer to the one used in the prior section is the standard deviation of the firm's rate of return about its own average. This measure is computed from

$$\sigma_i = \left[\frac{\sum_{t=1}^{n} (r_{it} - \bar{r}_i)^2}{n-1} \right]^{\frac{1}{2}}, \tag{18}$$

where σ_i = standard deviation of rates of return about the average for firm i;

r_{it} = rate of return in period t for firm i;

$\bar{r}_i$ = average rate of return over the period, firm i;

n = number of years included in the period.

Using this measure of risk, the statistical correlation between the firm's risk exposure and its average rate of return can be investigated for the firms included in the 11 industries. The simplest possible relationship is given in Eq. (19). Here the firm's average rate of return is expressed as the sum of an average risk-adjusted rate of return, r_0, plus an additional component that depends on the firm's risk exposure, $b\sigma_i$. This component of earnings is the risk premium that compensates firms for operating under conditions that lead to greater earnings variability:

$$\bar{r}_i = r_0 + b\bar{\sigma}_i \tag{19}$$

where $\bar{r}_i$ = average rate of return for firm i;

r_0 = average risk-adjusted rate of return for all firms;

σ_i = standard deviation of rates of return about the average for firm i;

b = marginal rate of profit per increment of dispersion.

Fig. 8 shows the relationship between the mean and the standard deviation for each of the 88 firms included in the 11 industry groups.

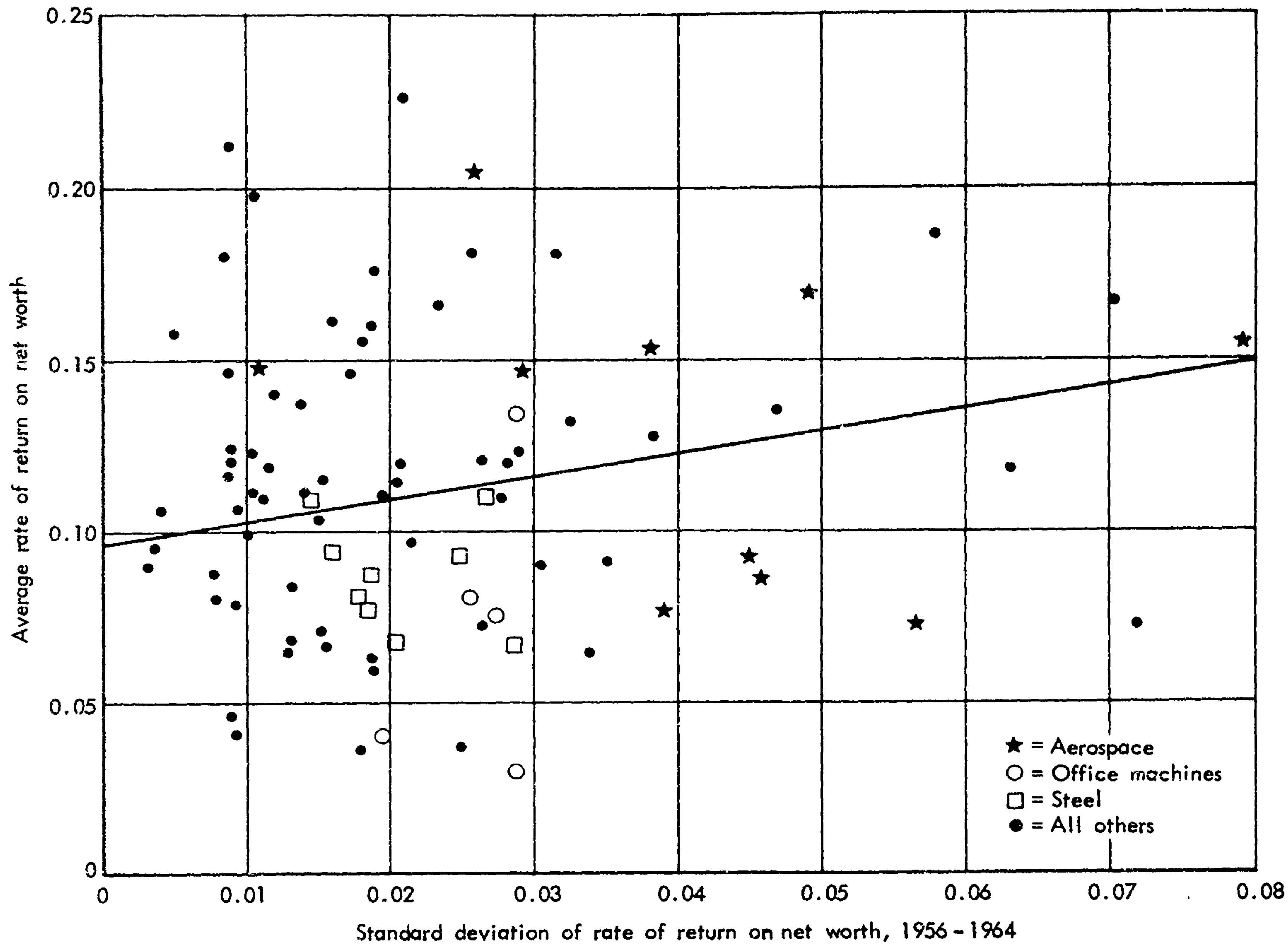

Fig. 8—Rate of return and standard deviation

Some industries show relatively little relationship between average return and variability. Office machinery and computers, a somewhat heterogeneous industry, is an example and this industry illustrates the problem of industry definition. Steel, on the other hand, is a relatively homogeneous industry in which all firms have similar rates of return and standard deviations. Other industry groups have a relatively obvious linear relationship between the means and standard deviations. The aerospace industry is an example, although there appear to be two distinct subgroups within this industry.

The data can be summarized by Eq. (20), which is also plotted in Fig. 8.

$$\bar{r}_i = 9.704 + \underset{(0.1595)}{0.6519}\sigma_i \qquad R^2 = 0.163 \tag{20}$$

The value of R^2 is not particularly impressive; it indicates that only 16 percent of the observed variations in average rates of return among these firms can be explained by differences in standard deviation.* Despite the low R^2, the coefficient of the standard deviation, b, is statistically significant at the 0.01 probability level. The average risk-adjusted rate of return for these firms, estimated by extrapolating the regression to the intercept, is 9.7 percent.

The low value of R^2 indicates that although there is some relationship between the average rate of return and this measure of risk, other factors apparently account for the major part of the observed differences in average firm rates of return. Dispersion is only one characteristic of the probability distribution of earnings; skewness is another that may help explain the observed differences.

Although firms may require a larger expected rate of return as the uncertainty of their potential earnings increases, they may also be

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*These results compare interestingly with Stigler's findings discussed earlier. The value for R^2 is higher than Stigler's data yielded. (Note that he shows R rather than R^2.) Also, the coefficients in Eq.(9) are not significant.

willing to accept a lower expected rate of return if the distribution of possible earnings outcomes is skewed in such a manner that there is some probability of receiving much larger than average earnings.* This situation is illustrated in Fig. 9. In (a), the distribution of returns is symmetrical about the average, so that the probability of receiving earnings greater than the expected value, $\bar{r}$, is identical to the probability of earnings that are lower by the same amount. In (b), however, there is a significant probability of receiving earnings much greater than the expected value, so that the firm may prefer this distribution to (a). Stated another way, the risk premiums may be lower for firms with a distribution of earnings similar to (b) rather than to (a).**

This hypothesis can be tested by including a measure of skewness in the relationship, so that it becomes

$$\bar{r}_i = r_0 + b_1\sigma i + b_2 S_i, \tag{21}$$

where S_i is the measure of skewness and b_2 is the coefficient of the skewness term. All other terms are the same as defined in Eq. (19).

The measure of skewness used here is the average of the cubed deviations from the mean divided by the cube of the standard deviation,*** and is computed from

$$S_i = \left[\frac{\sum_{t=1}^{n} (r_{it} - \bar{r}_i)^3}{n\sigma_i^3} \right], \tag{22}$$

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*This possibility has long been mentioned by theorists, but has not received much attention. See Ref. 6 and p. 125 of Ref. 12.

**It is widely believed that skewness is an important explanatory factor for the interindustry wage differentials. Movie acting and professional golf, for example, may be occupations where low average employee compensation is offset by the potential financial rewards of "stardom" or "championship." Also, in an empirical study of the stock market, Arditti found skewness to have a significant influence on average returns [3].

***If $S_i > 0$, the distribution is skewed to the right, as in Fig. 6(b), while if $S_i < 0$, it is skewed to the left. For Fig. 6(a) the value of

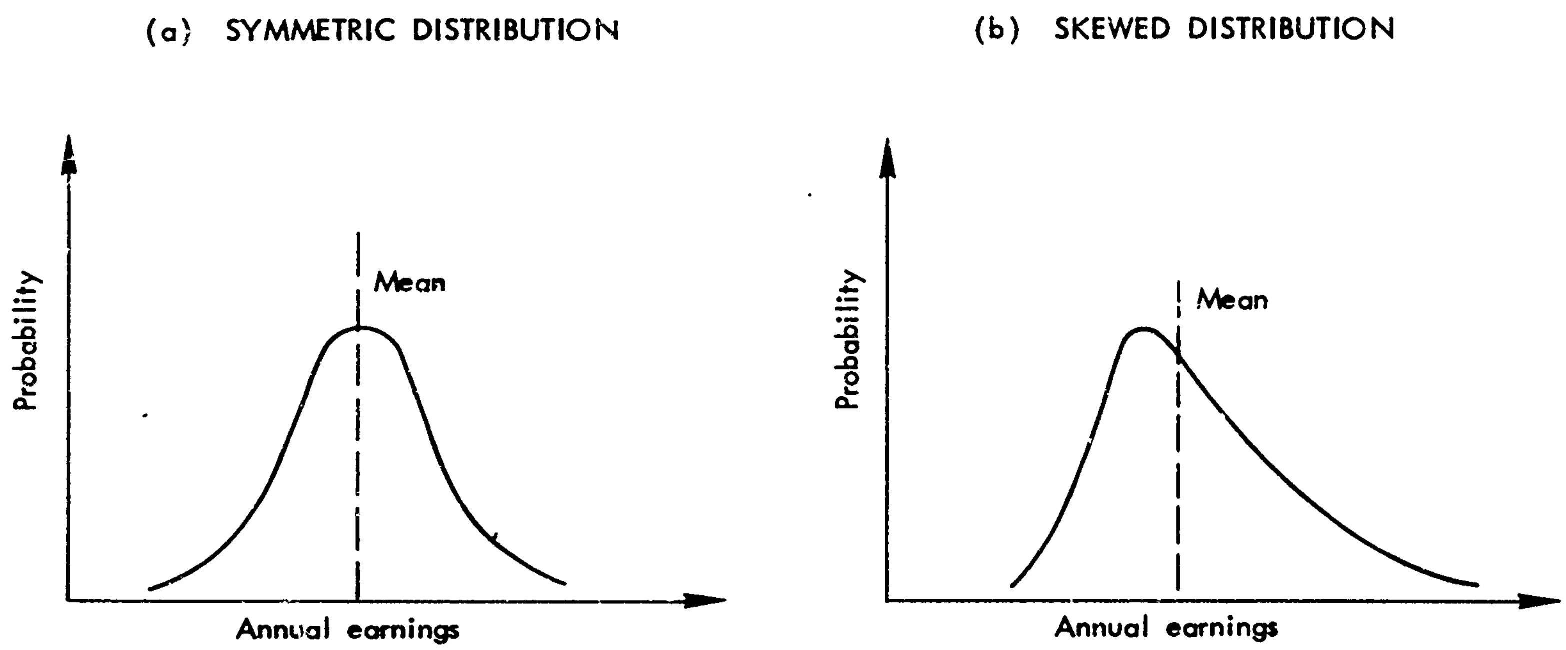

Fig. 9— Symmetric and skewed distributions of firm's earnings

where S_i = measure of skewness, $S_i \gtreqless 0$, for firm i;

σ_i = standard deviation of rates of return for firm i;

and all other terms are as previously defined.

Eq. (23) shows estimates for these coefficients. The risk-adjusted rate of return has not changed noticeably, nor has the value of the coefficient of the standard deviation, σ_i. The value of R^2 increased only slightly, indicating these two variables explain about 23 percent of the variance in average rates of return. Although the sign of the coefficient of skewness is as expected (that is, a positive value for skewness leads to a smaller rate of return), its value is not statistically significant in this formulation of the model.

$$\text{(23)} \qquad \bar{r}_i = 9.708 + \underset{(0.1600)}{0.6498\sigma_i} - \underset{(0.0708)}{0.0475\, S_i} \qquad R^2 = 0.234$$

In part this low correlation between rate of return and risk may be due to the influence of broad industry effects. Differences among industries in market structure, technology, average managerial ability, capital structure, and similar factors could produce industry differentials. Fig. 8 suggests the usefulness of making an adjustment for industry membership in the equation relating each company's rate of return to its risk exposure. To do this, we introduce into the equation a set of dummy variables for each of the 11 industry groups. The effect of these dummy variables is to shift the regression equation upward or downward from the intercept of Eq. (23) depending upon the group in which a particular firm is classified. The dummy or shift variables capture common influences for each group. These dummy variables become significant when the factors common to each industry differ from industry to industry. This procedure assumes, however, that there are no interaction effects between rate of return, risk, and industry. This use of

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$S_i = 0$. We have followed the usual practice of using the standard deviation rather than variance [4, pp. 24, 30]. This convention has the disadvantage, however, of resulting in different units of measurement for dispersion and skewness. Consequently, the explanatory power of these two terms cannot be directly compared.

shift coefficients does not permit different risk coefficients for different industries. The new relationship is

$$\bar{r}_{ij} = C_j + b\sigma_{ij}, \tag{24}$$

where $\bar{r}_{ij}$ = average rate of return for firm i in industry j;

C_j = dummy variable for industry group j, the risk-adjusted rate of return for group j;

σ_{ij} = standard deviation of rate of return for firm i, industry j;

The numerical values are shown in Table 5.

Just as in the previous formulation -- Eqs. (20) and (23), where the intercept coefficient was interpreted as a risk-adjusted rate of return -- so the C_j's represent average risk-adjusted rates of return for each group. They are the average profit rate for each group after allowing for the influence of risk on rates of return.

The coefficient of the standard deviation, b, is increased by adding the dummy variables for group membership. The value of R^2 also increased substantially. In this formulation, over 45 percent of the rate of return variance is explained by the independent variables. Partitioning the sample by industry group considerably increases the explanatory power of the model.

Table 5

INDUSTRY RISK-ADJUSTED RATES OF RETURN

b	R^2	C_j	Industry
.8522	.459	.0791	Aerospace
(.2295)		.0893	Rubber
		.1001	Petroleum
		.0883	Electrical machinery
		.0668	Steel
		.1541	Drugs
		.0595	Textiles
		.0892	Food
		.0655	Automobiles
		.1124	Chemicals
		.0696	Office Machines

Equation (24) also permits computation of industry group risk premiums. Each C_j can be interpreted as an average risk-adjusted rate of return for firms in that industry group. Therefore, the difference between the unadjusted rate of return for industry j and the coefficient C_j is the average risk premium for the firms in the industry. Table 6 shows the unadjusted average rate of return, the risk-adjusted rate of return (C_j), and the difference or risk premium for each industry.

This method, which will shortly be replaced by a more sophisticated version, yields risk premiums that vary substantially among industries. For the aerospace group, the risk premium accounts for nearly half the unadjusted average earnings. Risk premiums account for even larger proportions of unadjusted profit rates for other groups. In a comparison of risk-adjusted rates of return, the aerospace group, instead of ranking second, falls in the middle of the eleven groups.

MEASUREMENT TECHNIQUE DIFFERENCES--A DIGRESSION

It was previously asserted that the measurement of dispersion we have adopted -- the temporal/firm dispersion -- yields results different from the intraindustry dispersion measure like that used by Cootner and Holland. In most cases, the adjusted rates of return are much the same regardless of which technique is used. Several industries, however, reveal substantially different rates of return. This can be seen by comparing Tables 4 and 6. For convenience, the adjusted rates of return are also shown in Table 7.

The most interesting comparison involves the drug group. Using the standard deviation of firm rates of return about the industry average results in a risk premium of nearly 8 percent (Table 4); the average risk premium computed in Table 6 for the drug firms is less than 1 percent. The reason for this is that there is a substantial spread among the average earnings of drug firms but the earnings of each firm have been relatively stable during the period. As we have already pointed out, intraindustry dispersion may be misleading as a measure of industry risk exposure, and the drug industry exemplifies the difficulties that can arise. Nonetheless, given the stability of earnings for the firms in this industry, we would argue that there is

Table 6

RATES OF RETURN FOR 11 INDUSTRY GROUPS, 1956-1964, ADJUSTED FOR TEMPORAL/FIRM DISPERSION

Industry	Rate of Return		Risk Premium
	Unadjusted	Adjusted	
Drugs	.1632	.1541	.0091
Aerospace	.1560	.0791	.0769
Automobiles	.1477	.0655	.0822
Chemicals	.1409	.1124	.0285
Office machines	.1408	.0696	.0712
Electrical machinery	.1195	.0883	.0312
Petroleum	.1147	.1001	.0146
Rubber	.1096	.0893	.0203
Food	.1072	.0892	.0180
Steel	.0825	.0668	.0157
Textiles	.0789	.0595	.0194

Table 7

RISK-ADJUSTED RATE OF RETURN COMPARISON

Industry	Dispersion-Adjusted Rate of Return	
	Intraindustry	Temporal/Firm
Drugs	.0842	.1541
Aerospace	.0752	.0791
Automobiles	.0619	.0655
Chemicals	.0911	.1124
Office machines	.0605	.0696
Electrical machinery	.0596	.0883
Petroleum	.0898	.1001
Rubber	.0791	.0893
Food	.0604	.0892
Steel	.0566	.0668
Textiles	.0487	.0595

little uncertainty about their expected earnings and, consequently, relatively little risk exposure for established drug firms.

ADJUSTMENTS TO THE MODEL

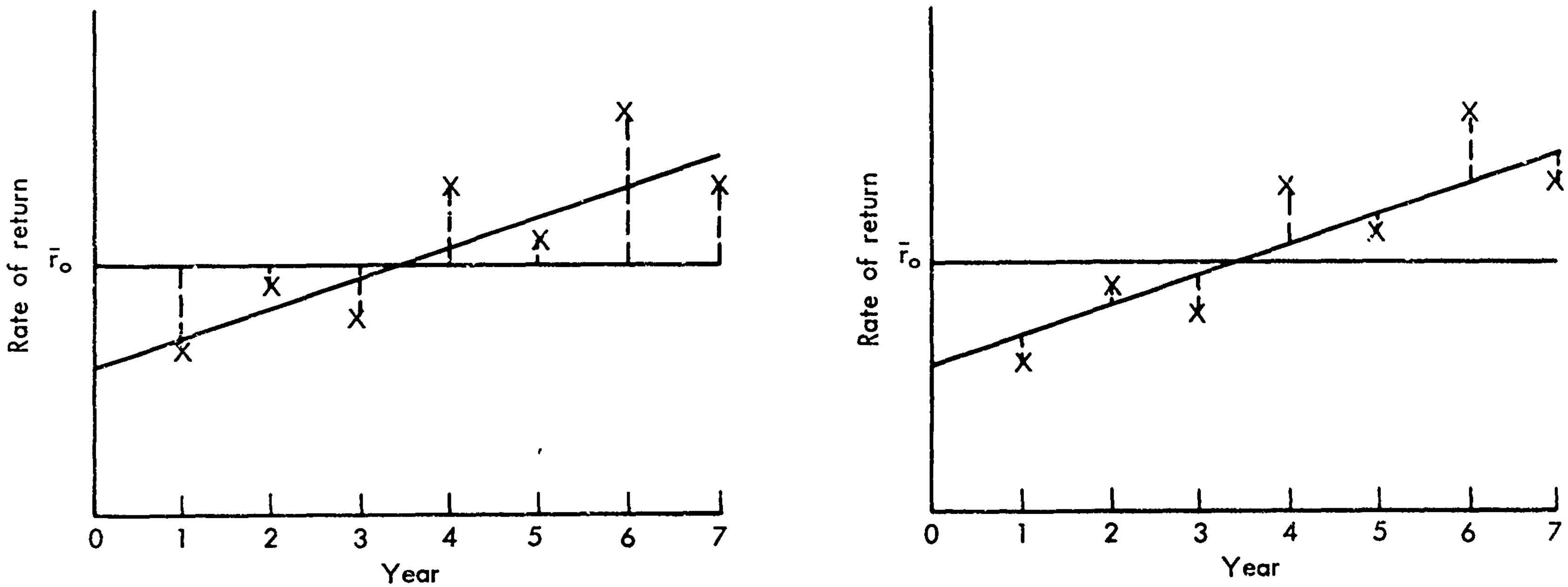
The analysis to this point has a serious flaw. Section II developed the concept of risk as being the likelihood that forecasts will prove incorrect. This likelihood was in turn identified with dispersion of realized returns about the firm's average return. The problem is that variance need not necessarily imply forecasting difficulty. If there are time trends in the deviations, or if some other known factor controls the deviations, then they may be predicted. Consequently, before accepting the results of our prior formulation of the model, it is necessary to adjust for time trends and autocorrelation.

Trend Adjustment

Continuing changes in technology, demand, capacity utilization, and so forth may produce an upward or downward pattern of earnings over time. If so, the standard deviation will be larger than it should be if risk is defined as the inability to predict future earnings accurately.

To illustrate, suppose the earnings pattern of a hypothetical firm is as shown in Fig. 10(a). Because of the upward trend in earnings, measurement of deviations about the mean value will show a large standard deviation. The entrepreneur, however, will presumably build this trend into his anticipations. Consequently, if we think of risk as the likelihood that the expected outcome will differ from the actual, the standard deviation about the mean overstates the uncertainty.

To remove this effect, the standard deviation can be measured about a trend line fitted to the observed rates of return, as shown in Fig. 10(b). If there is a trend, the standard deviation computed in this manner will be smaller than when computed about the average, indicating less earnings uncertainty and, consequently, smaller risk exposure. When there is no trend present, the trend line is equivalent to the average and the two methods of computing the standard deviation are equivalent.



(a) Deviations about average, $\bar{r}_o$

(b) Deviations about trend

Fig. 10—Measurement of deviations about means and trend

An alternative measure of risk has been computed from

$$(25) \qquad \sigma_i^t = \left[\frac{\sum_{t=1}^{n} (r_{it} - \hat{r}_{it})^2}{n - 1} \right]^{\frac{1}{2}}$$

where σ_i^t = standard deviation of rate of return about a trend for firm i, industry group j;

r_{it} = rate of return for firm i in year t;

$\hat{r}_{it}$ = predicted rate of return for firm i in period t from trend; i.e., $\hat{r}_{it} = r'_o + b_i t$.

Using this modified standard deviation as a measure of the firm's risk exposure, the risk-premium function of Eq. (24) becomes

$$(26) \qquad \bar{r}_{ij} = C_j + b\sigma_{it}^t$$

where C_j = dummy variable for industry group j; the risk-adjusted rate of return for industry group j;

$\bar{r}_{ij}$ = average rate of return for firm i in industry j;

σ_{ij}^t = standard deviation of rates of return about the trend for firm i in industry group j.

Estimates for these coefficients are shown in Table 8. Note that in most cases the risk-adjusted rates of return for each industry grouping are nearly identical to those computed without eliminating the trend effect shown in Table 6. Two groups, however, aerospace and automobiles, have very different trend-adjusted rates. Eliminating the trend from firm earnings in each industry group has resulted in a larger average risk-adjusted rate of return and, consequently, a smaller risk differential for each of these industry groups. Some of what previously appeared to be earnings variability for these firms was the result of time trend rather than actual earnings uncertainty.

Autocorrelation Adjustment

A second reason for questioning the validity of the standard deviation as a measure of risk exposure is the possibility that the firm's annual profit rates are autocorrelated. The firm's earnings may be serially correlated, resulting in a standard deviation that overstates the extent of the year-to-year variability. This possibility is illustrated in Fig. 11. Although the standard deviation about a trend line will be large, earnings can be predicted from knowledge of the autoregressive structure and, consequently, earnings uncertainty and risk exposure will be overstated.

Table 8

INDUSTRY RISK-ADJUSTED RATES OF RETURN

Rates Adjusted for Trend Effects

b	R^2	C_j	Industry
.9440	.4990	.1153	Aerospace
(.3469)		.0929	Rubber
		.1013	Petroleum
		.0893	Electrical machinery
		.0659	Steel
		.1571	Drugs
		.0597	Textiles
		.0878	Food
		.0752	Automobiles
		.1146	Chemicals
		.0690	Office machines

After removal of the trend effect, the earnings pattern for each firm in the sample was tested for autocorrelation.* Evidence of

*The Durbin-Watson statistic, D, was computed for each firm in the sample and compared with the critical values obtained from published tables. (See Ref. 5 for the definition of D.) The test is as follows:

if $D < D_L$, the test indicates positive serial correlation;

if $D > D_U$, the test indicates no positive serial correlation;

if $D_L < D > D_U$, the test is inconclusive.

Nine firms for which $D < D_L$ (1.08 at the 5-percent level) were excluded from the sample.

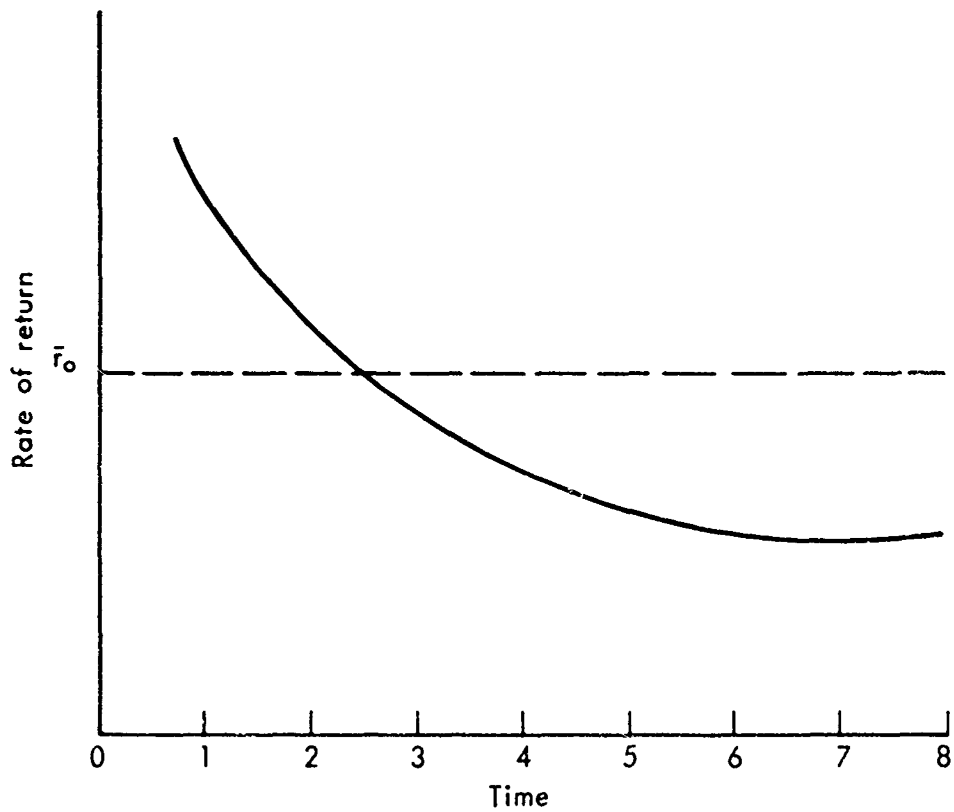


Fig. 11—Autocorrelated earnings

positive serial correlation was found for nine of the firms including three drug and three aerospace firms. In order to eliminate the effect of autocorrelation on the estimated risk-adjusted rates of return and risk premiums, these firms were removed from the sample and Eq. (26) re-estimated.* The values of these coefficients appear in Table 9. Note that the average risk-adjusted rates of return for the aerospace and drug firms are larger than those contained in Table 8. This suggests that part of the earnings differential previously attributed to risk

Table 9

INDUSTRY RISK-ADJUSTED RATES OF RETURN, ADJUSTED FOR TREND AND AUTOCORRELATION

b	R^2	C_j	Industry
1.1087	.4907	.1294	Aerospace
(.3697)		.0914	Rubber
		.0996	Petroleum
		.0872	Electrical machinery
		.0643	Steel
		.1678	Drugs
		.0587	Textiles
		.0845	Food
		.0721	Automobiles
		.1100	Chemicals
		.0674	Office machines

may be explained by the larger standard deviations resulting from the autoregressive structure of the earnings for these firms.

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*The general effect of eliminating these firms from the sample is to increase the estimated risk-adjusted rates of return for these industries. This occurs because firms with autocorrelated annual earnings generally have lower average rates of return than those of other firms in the industry; eliminating them increases both the industry average rate of return and average risk-adjusted rate of return. Elimination of these firms is consistent with our argument that risk should reflect earnings uncertainty. These firms have less earnings uncertainty (and less risk-exposure) by virtue of the autoregressive structure of their earnings pattern than do other firms; including them in the sample understates the estimated risk-adjusted rates of return for these industries.

The Revised Relationship

Eliminating the effects of trend and autocorrelation from the data has significantly affected the statistical relationship between the rate of return and standard deviation. This raises the possibility that skewness may also be a more important factor in explaining observed rates of return after eliminating the other effects. A final equation that includes both standard deviation and skewness as explanatory variables is given by Eq. (27).

$$\bar{r}_{ij} = b_1 \sigma^t_{ij} = b_2 S^t_{ij} + C_j, \tag{27}$$

where σ^t_{ij} = standard deviation of rates of return about the trend for firm i in industry group j;

S^t_{ij} = measure of skewness of rates of return about the trend for firms in industry j;

C_j = shift variables for industry group; $j = 1, \ldots, 11$.

Estimates for b_1, b_2, and the C_j's appear in Table 10. Including skewness in the relationship improved slightly the coefficient of determination (after correcting for degrees of freedom) and also decreased the coefficient of the standard deviation, b_1. The coefficient of skewness, b_2, again has a negative sign and is statistically significant at the .05 level of confidence (although not at the .01 level), suggesting that skewness as well as dispersion may play a role in explaining differentials observed in average firm rates of return.

Including skewness in the relationship has also had some effect on the values of the C_j's for most industry groups (compare Table 9). The most noticeable change occurs for the rubber industry, where the risk-adjusted rate of return has risen from .091 to .102. Changes in average rates of return for other industry groups are, for the most part, of less magnitude.

SUMMARY

One point the analysis reveals is the significance of the conceptual and statistical measure of risk adopted. At the conceptual level, we have identified risk with the predictability of the firm's future earnings as measured by the distribution of earnings, a view that has a sound theoretical rationale. Translation of this concept into a statistical measure of risk presents some challenging issues, however. We have argued for measuring the dispersion of firm rates of return around their own temporal means or around their own time trend lines rather than measuring dispersion in terms of the deviation

Table 10

INDUSTRY RISK-ADJUSTED RATES OF RETURN, ADJUSTED FOR TREND AND AUTOCORRELATION

b_1	b_2	R^2	C_j	Industry
1.0043	-.0153	.4936	0.1335	Aerospace
(.3648)	(.0081)		0.1021	Rubber
			0.1026	Petroleum
			0.0857	Electrical machinery
			0.0703	Steel
			0.1664	Drugs
			0.0594	Textiles
			0.0915	Food
			0.0754	Automobiles
			0.1131	Chemicals
			0.0724	Office machines

of firm means from industry averages.

Using our statistical measure of risk, we have examined the risk premiums associated with the standard deviation and skewness of the earnings of 88 firms. To make this statistical measure consistent with the theoretical concept of risk, several adjustments were required. The final formulation of the model, presented in Eq. (27), is repeated below:

$$\bar{r}_{ij} = b_1 \sigma_{ij}^t + b_2 S_{ij}^t + C_j, \tag{27}$$

where σ^t_{ij} = standard deviation of rate of return about the trend for firm i in industry group j;

S^t_{ij} = measure of skewness of rates of return about the trend for firm i in industry group j;

C_j = shift variable for industry group, j = 1, ..., 11; and firms with substantial earnings autocorrelation removed from the sample.

The statistical estimates for this relationship are shown above in Table 10. Not quite half of the variance is explained, and statistically significant coefficients are obtained for the standard deviation and skewness terms. The C_j's, the shift coefficients or risk-adjusted rates of return for each group, are not only interesting in themselves, but provide an easy way to assess the impact of the various explanatory variables used in the model and the adjustments made for trend and autocorrelation. Table 11 compares these risk-adjusted rates and the risk premiums computed from them.

One of the most interesting points this comparison illustrates is that risk significantly affects average industry rates of return, no matter which variables or adjustments are included in the model. The average risk premium for each of the industry groups is substantial, ranging from about 1½ percentage points for petroleum to more than 7 percentage points for the automobile group.

Adjustments are necessary to remove trend effects and autocorrelated disturbances. Table 11 illustrates this effect on the estimated risk-adjusted rates of return and risk premiums. For most industries the effects of trend and autocorrelation are negligible, but this is not the case for drugs and aerospace. For the aerospace group, the estimated risk-adjusted rate of return becomes larger (and the estimated risk premium correspondingly smaller) as trend and autocorrelation effects are eliminated. These two effects account for more than half the differential that was initially attributed to risk, and show the importance of eliminating these effects.

For the drug firms, trend appears to have had little effect on the estimated values; the most noticeable effect results from autocorrelation. In this case, eliminating the autocorrelated firms from the sample results in a larger risk-adjusted rate of return and also a larger

Table 11

COMPARISON OF AVERAGE RISK-COMPENSATED RATES OF RETURN AND RISK PREMIUMS

A. Average Risk-Compensated Rates of Return

Industry	Unadj.	Adjusted for: Dispersion	Dispersion, Trend	Dispersion, Trend, Autocorrelation	Dispersion, Trend, Autocorrelation, Skewness
Drugs	.1632	.1541	.1571	.1678	.1664
Aerospace	.1560	.0791	.1153	.1294	.1335
Automobiles	.1477	.0655	.0752	.0721	.0754
Chemicals	.1409	.1124	.1146	.1100	.1131
Office mach.	.1408	.0696	.0690	.0674	.0724
Elect. mach.	.1195	.0883	.0893	.0872	.0857
Petroleum	.1147	.1001	.1013	.0996	.1026
Rubber	.1096	.0893	.0929	.0914	.1021
Food	.1072	.0892	.0878	.0845	.0915
Steel	.0825	.0668	.0659	.0643	.0703
Textiles	.0789	.0595	.0597	.0587	.0594

B. Average Risk Premiums

Industry	Dispersion	Dispersion, Trend	Dispersion, Trend, Autocorrelation	Dispersion, Trend, Autocorrelation, Skewness
Drugs	.0091	.0061	.0157[a]	.0168[a]
Aerospace	.0769	.0407	.0284[a]	.0245[a]
Automobiles	.0822	.0725	.0756	.0723
Chemicals	.0285	.0263	.0309	.0278
Office mach.	.0712	.0718	.0734	.0684
Elect. mach.	.0312	.0302	.0323	.0338
Petroleum	.0146	.0134	.0151	.0121
Rubber	.0203	.0167	.0182	.0075
Food	.0180	.0194	.0227	.0157
Steel	.0157	.0166	.0182	.0122
Textiles	.0194	.0192	.0192	.0185

[a]Eliminating the autocorrelated firms altered the unadjusted industry average rate of return to 0.183 for the remaining drug firms and to 0.157 for the aerospace firms. The risk premium is the difference between these values and the risk-compensated rates of return also computed for the nonautocorrelated sample.

average risk premium. This occurs because there is an increase in the industry average rate of return and the risk-adjusted average, resulting in a larger average risk premium. The presence of autocorrelation in this case tends to understate the risk premium.

Although adjusting industry earnings to reflect differences in risk exposure has narrowed interindustry earnings differentials, significant differences remain in average risk-adjusted rates of return. Those for the drug, aerospace, and chemical industries, for example, are noticeably larger than for the remaining groups. One might be tempted to interpret this as indicating that profits have perhaps been too large in these industries. It is important to understand why this interpretation is not appropriate. A risk premium is but one of several components of profits that can lead to interfirm and interindustry earnings differentials. Other components of profits may be equally as important as risk in explaining these observed differences. If industry differentials persist after accounting for these other factors, relative comparisons between adjusted industry earnings are relevant. One can infer from the estimates in Table 11 that drug, aerospace, or chemical profits are in some sense excessive only if these earnings differentials cannot be explained by investment, innovation, technology, and other profit rate determinants.

In summary, the risk premium is an important component of the earnings for the firms in our sample. Although these risk premiums are significant, substantial interindustry differences remain unexplained; these, presumably, are explained by other profit components. However, until industry earnings have been adjusted to reflect the contribution of all the various profit components, the estimates presented here are of risk-comparable profits rather than comparisons of "adequate" profits.

IV. CONCLUSIONS

This study has addressed the twin problems of defining and measuring the risk component of profits, with emphasis on aerospace firms. Aerospace firms have generally earned high rates of return on investment. To what extent is this due to the "riskiness" of the industry? An answer to this question requires that a number of conceptual and statistical issues be resolved. Consequently, a large part of this study has been devoted to theoretical and methodological considerations. The result of this exploration, we believe, is a procedure for meaningful assessment of the relationship between risk and average rate of return. It is important, nonetheless, to emphasize that empirical results are importantly influenced by the measurement technique adopted and the underlying theoretical concepts.

THE MEASUREMENT OF RISK

There is a vital distinction between studies of profit comparability, such as this one, and studies of profit adequacy. The latter type of study requires evaluation of all relevant profit components. The former type has the still difficult but simpler task of trying to adjust nominal profits for differences in one factor. In the present study this factor is risk. We have estimated risk-adjusted rates of return for a sample of large firms. That is, we have computed risk premiums and rates of return that reflect equal risk exposure for a sample of firms in 11 industry groups. These risk-adjusted rates of return, however, should not be interpreted as measuring the social appropriateness of the various corporate profits, because the analysis does not allow for profit-affecting factors other than risk.

The first measurement issue that has to be resolved is the base for the rate of return calculations. We have used net worth because this appears to be the best measure of stockholder's equity. Risk compensation is most meaningfully evaluated in terms of premiums required to attract investment. Therefore, the return to stockholders appears the most useful measure of profits.

The definition of risk is a more complex problem. Risk is here defined as the inability to forecast with a probability of 1.0 future outcomes of some event. More precisely, risk is the probability that earnings in a future period will differ from an anticipated value. Coupling this definition with the assumption that, on the average, entrepreneurial expectations are fulfilled permits empirical measurement of risk exposure. The measure is the dispersion of observed earnings from the mean value. Specifically, we assume that, on the average, entrepreneurial expectations of the mean rate of return to be earned during some period are equal to the rate of return actually earned. Therefore, risk, as the term is used here, can be measured by the standard deviation and skewness of earnings.*

If the standard deviation and skewness of earnings are adopted as the measure of risk, a further measurement issue arises: how these quantities are to be computed. One option is to use the deviations of firm-average rates of return around the industry mean. This method was rejected. If risk is the relationship between expected and actual outcomes, it is hard to see why firms would form anticipations based on industry averages; presumably, their own experience is a superior basis for prediction. Consequently, the measures are computed from the deviations of each firm's annual rate of return about its own mean.

The choice of a measurement technique is not merely a theoretical matter; it importantly affects the statistical results. Risk-adjusted rates of return were derived using standard deviations computed by both methods. Under the first method, the firm-to-industry-mean dispersion, the drug group had a risk-compensated rate of return of 8 percent and aerospace 7.5 percent. Under the method advocated in this study, the results were 15 percent for drugs and 8 percent for aerospace (without adjusting for trend or autocorrelation). This difference is due to differences in the earnings patterns. Drug firms vary widely in their long-run rates of return. Each firm, however, has about the same rate of return from year to year. The reverse is true for aerospace firms:

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*For caveats about this definition of risk see pp. 10-12.

the long-run average rates of return are about the same, but each firm has substantial year-to-year fluctuations in earnings. One's method of measuring risk strongly influences the inference one draws about risk-exposure. On theoretical grounds we believe that the best method is to utilize deviations of firm rates of return from their own mean.

STATISTICAL FINDINGS

The sample consisted of yearly rates of return for 88 firms for the years 1956 to 1964. Relationships between the mean rate of return and two dimensions of the distribution were examined. These dimensions were the standard deviation and skewness. At the simplest level, taking all 88 firms as a group and regressing rate of return on the other two variables produced a significant relationship between rate of return and standard deviation, as shown in Eq. (28). Skewness was not significant and only a small amount of variance was explained.

$$\bar{r}_j = 9.704 + \underset{(.1595)}{.6519}\sigma_j; \qquad R^2 = .163 \tag{28}$$

Inspection of the data indicated that there are some obvious relationships among firms within industry groups. Consequently, including a dummy variable to represent industry groups both increased the explanatory power of the relationship and provided industry coefficients $[C_j]$ that were estimates of the risk-adjusted rate of return for that group. Thus:

$$\bar{r}_{ij} = C_j + .85220\sigma_{ij} \qquad R^2 = .459 \tag{29}$$

where C_j = 0.0791 for aerospace
0.0893 for rubber
0.1001 for petroleum
0.0883 for electrical machinery
0.0668 for steel
0.1541 for drugs
0.0595 for textiles
0.0892 for food
0.0655 for automobiles
0.1124 for chemicals
0.0696 for office machines

This equation explains almost 46 percent of the variation in profits as measured by the standard deviation, after allowing for differences in the industry rates of return. Also, note the substantial differences in the C_j coefficients -- the intercept for each industry. Nonetheless, less than half the difference in firm rates of return can be explained by risk. The greater part of the variation has to be explained on other grounds.

The C_j coefficient, when subtracted from the value of the average rate of return, yields an estimate of the risk premium for that group of firms. For most groups this premium is not large -- 1 or 2 percentage points. For two industries, however, the risk premium is substantial: 8.2 percent for automobiles and 7.6 percent for aerospace. This result means that the risk-adjusted profit rate for aerospace drops from the nominal 15.6 percent to 7.9 percent. In rank by rate of return, this is a drop from the second highest to sixth. The results for the group that has the highest rate of return, drugs, provides an interesting contrast. There is almost no risk premium (0.9 percent) so the nominal rate of return of 16.3 percent becomes a risk-adjusted rate of return of 15.4 percent. This is still the highest rate by a substantial margin.

It would appear from these figures that the risk-adjusted rate of return for aerospace is quite comparable to the risk-adjusted rate of return for other groups. Before this view can be accepted, however, the results must be examined in light of the theoretical model. Since risk is viewed as unpredictability, one must adjust for other relationships between the mean and variance that would improve forecasting and, consequently, reduce risk-exposure. Two such relationships were examined, trend and autocorrelation. Interestingly, these factors primarily affected the groups with the highest nominal rates of return -- drugs and aerospace.

Removing the effect of trend and discarding the 9 firms with autocorrelated error terms produces the following relationship between rate of return and standard deviation:

$$(30) \qquad \bar{r}_{ij} = C_j + 1.1087\sigma_{ij} \qquad R^2 = .4907$$

where C_j = 0.1294 for aerospace
0.0914 for rubber
0.0996 for petroleum
0.0872 for electrical machinery
0.0643 for steel
0.1678 for drugs
0.0587 for textiles
0.0845 for food
0.0721 for automobiles
0.1100 for chemicals
0.0674 for office machines

Comparing these C_j coefficients with those presented previously shows that the one important change is in the aerospace coefficient. In terms of risk-adjusted rates of return, aerospace jumps from 7.9 to 12.9 percent when allowance is made for trend and autocorrelation. Aerospace regains its previous position with the second highest rate of return. The only higher rate is that for drugs, which ranks first no matter how the data are adjusted.

Adjusting for trend and autocorrelation reintroduces the question of the effect of skewness. Using unadjusted data, skewness has a statistically insignificant impact. After making the required adjustments, however, skewness becomes more significant The final relationship is:

$$(31) \qquad \bar{r}_{ij} = C_j + 1.10043\sigma^t_{ij} - .0153S^t_{ij} \qquad R^2 = .4936$$

where σ^t_{ij} = standard deviation of rate of return about the trend for firm i in industry group j;

S^t_{ij} = measure of skewness of rates of return about the trend for firm i in industry group j; and

C_j = shift variables for industry group; i = 1 ..., 11.

The C_j's are:

0.1335 for aerospace
0.1021 for rubber
0.1026 for petroleum
0.0857 for electrical machinery
0.0703 for steel
0.1664 for drugs
0.0594 for textiles
0.0915 for food
0.0754 for automobiles
0.1131 for chemicals
0.0724 for office machines

IMPLICATIONS

On the theoretical level, the results indicate that the average rates of return for the firms included in the study were importantly influenced by risk. Firms with high standard deviations had higher mean profit rates while firms with positively skewed earnings distributions had lower profit rates. The implication is that, for this sample, entrepreneurs were both risk-averse and liked positive "long shots."

On the statistical level, it is important to note that several adjustments were required to obtain empirical relationships that accord with theoretical concepts. The adjustments for trend and autocorrelation were particularly important. While earnings variations for most industry groups were not influenced strongly by trends and autocorrelation, these adjustments significantly changed the implications to be drawn about the aerospace group.

On the policy level, the important implication concerns the risk component of aerospace industry profits. If entrepreneurs are risk averse (and the results here indicate they are), above-average risk exposure requires above-average profits. Does this explain the aerospace industry rate of return? The results of this investigation indicate the answer is no. The risk-compensated rate of return for aerospace is still one of the highest among the 11 groups examined. Specifically, it is the second largest, exceeded only by the drug group. Interestingly, comparing the nominal rates of return before any adjustments are made, aerospace has the second highest rate of return again exceeded only by drugs. Thus, the explanation for aerospace's rate of return must be sought in some factor other than risk.

Appendix

FIRMS INCLUDED IN SAMPLE

Industry Group and Firm

1. DRUGS

   Abbott Laboratories
   Mead Johnson & Company
   Merck & Company
   Pfizer (Chas.) & Company, Inc.
   Rexall Drug & Chemical Company
   Schering Corporation
   Smith, Kline & French Laboratories, Inc.
   Sterling Drug, Inc.
   Warner-Lambert Pharmaceutical Company

2. AEROSPACE

   The Boeing Company
   Cessna Aircraft Company
   Curtiss-Wright Corporation
   Douglas Aircraft Company, Inc.
   Lockheed Aircraft Corporation
   McDonnell Aircraft Corporation
   North American Aviation, Inc.
   Northrop Corporation
   Republic Aviation Corporation
   United Aircraft Corporation

3. AUTOMOBILES AND TRUCKS

   American Motors Corporation
   Chrysler Corporation
   Ford Motor Company
   General Motors Corporation
   Mack Trucks, Inc.
   Studebaker-Packard Corporation
   The White Motor Company

4. CHEMICALS

   Allied Chemical Corporation
   The Dow Chemical Company
   E. I. Du Pont De Nemours & Company
   Hooker Chemical Corporation
   Interchemical Corporation

Koppers Company, Inc.
Monsanto Chemical Company
Stauffer Chemical Company
Union Carbide Corporation

5. OFFICE MACHINES AND COMPUTERS

Addressograph-Multigraph Corporation
Burroughs Corporation
International Business Machines Corp.
Royal McBee Corporation
Smith-Corona Marchant, Inc.
Sperry Rand Corporation

6. ELECTRICAL MACHINERY AND APPLIANCES

Admiral Corporation
The Emerson Electric Manufacturing Co.
General Electric Company
International Telephone & Telegraph Corp.
The Magnavox Company
Motorola, Inc.
Radio Corporation of America
Westinghouse Electric Corporation
Whirlpool Corporation

7. PETROLEUM

Continental Oil Company
Gulf Oil Corporation
Socony Mobil Oil Company, Inc.
Phillips Petroleum Company
Shell Oil Company
Standard Oil Company (California)
Standard Oil Company (New Jersey)
Texaco, Inc.

8. RUBBER

The Armstrong Rubber Company
The Firestone Tire & Rubber Company
The General Tire & Rubber Company
The B. F. Goodrich Company
The Goodyear Tire & Rubber Co.
United States Rubber Company

9. FOOD

Armour & Company
Beatrice Foods Company
The Borden Company
Corn Products Company

General Foods Corporation
John Morrell & Company
National Dairy Products Corporation
Standard Brands, Inc.
Swift & Company

10. STEEL

Armco Steel Corporation
Bethlehem Steel Corporation
Inland Steel Company
Jones & Laughlin Steel Corp.
National Steel Corporation
Republic Steel Corporation
United States Steel Corporation
The Youngstown Sheet & Tube Company

11. TEXTILES

Allied Chemical Corporation
Cannon Mills Company
Celanese Corporation of America
Chemtron Corporation
Cane Mills Corporation
Dan River Mills, Inc.
Textron, Inc.

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10. ABSTRACT

The relationship between risk and profit is explored and a method for measuring the risk component of corporate earnings is developed. Average risk premiums and risk-adjusted rates of return are estimated for aerospace and 10 other industry groups. Risk is defined as the probability that earnings in some future period will differ from an anticipated value. Assuming that, on average, profit expectations are fulfilled, risk can be measured by characteristics of the earnings distribution. Standard deviation and skewness are the statistical variables used to measure the firm's risk exposure. A statistically significant relationship is found between average rates of return on net worth and both standard deviation and skewness. Average risk adjusted rates of return are estimated for each industry group and compared with nominal rates of return. The risk-adjusted rates of return for drugs and aerospace are noticeably larger than those for the other industry groups. This finding implies that, for this sample, above-average rates of return in the aerospace group cannot be explained by above-average risk exposure. ()

11. KEY WORDS

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70